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Workshop Report On Sustainable Urban Development

Authors:

Dr. Stephanie Langhoff
Chief Scientist
Ames Research Center, Moffett Field, California

Dr. Gary Martin
Director, New Ventures and Communications Directorate
Ames Research Center, Moffett Field, California

Dr. Larry Barone
Research Scientist, Bay Area Environmental Research Institute
Ames Research Center, Moffett Field, California

Dr. Wolfgang Wagener
Director, Sustainable Cities
Cisco Connected Urban Development Group,
San Jose, California

Report of a workshop
sponsored by and held at
NASA Ames Research Center
Moffett Field, California
on January 9-10, 2009

June 2009

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Executive Summary

Focusing on Sustainable Urban Development Challenges

Bay Area leaders face significant challenges in their efforts to manage the region's urban environments in a sustainable manner. Participants at the "Sustainable Urban Development" workshop, hosted by the NASA Ames Research Center on January 9th and 10th, 2009, discussed those challenges with the explicit goal of exploring how the application of NASA science and technology could best support those efforts.

While the focus was on the greater San Francisco Bay Area, the workshop covered ground applicable to urban management at the local, regional and global scales. Representatives from the cities of Mountain View, Sunnyvale, San Jose, and San Francisco discussed their current strategies, programs, and projects for moving to a more sustainable future. Researchers and managers from NASA explored how remote sensing, modeling, computing, visualization, and decision support systems can contribute to creating and managing a sustainable urban environment. Presenters from universities, research institutions, and a range of public agencies extended these discussions, covering a range of topics and ideas from the monitoring of individual appliances in the home, to management of the grid, to the comparative assessment of cities from new satellite-based information systems.

The workshop helped NASA and other researchers better understand the problems facing urban managers and to make city and public agency leaders in the Bay Area more aware of NASA's capabilities. By bringing members of these groups together, we also seeded new collaborations between NASA, other research and advocacy groups, and those faced with instituting sustainable urban management in Bay Area cities.

Sharing Perspectives, Problems and Opportunities

City and public agency leaders discussed a range of current strategies and programs targeted at sustainable urban management and development. Current efforts include providing incentives for green buildings, improving recycling and energy efficiency, recycling wastewater for landscape irrigation, greening vehicle fleets, etc. Another approach has been to implement new Internet sites and information and communication technologies to encourage their citizens to become greener. One example is the EcoMap project in San Francisco, which is a geo-mapping based, collaboration, visualization, and measurement tool for citizens, businesses and city authorities. It enables the measurement of carbon emissions aggregated by zip-code, neighborhoods, and at the city-wide scale. One aspect of the program is the solar map initiative to promote the use of solar power for private and commercial buildings. A single location on the Internet provides a comprehensive overview of related resources such as installers, solar rebates, and tax credits.

NASA researchers and program managers covered research and technologies that bear on sustainable urban management, including remote sensing and climate, carbon and ecosystem modeling, and high-end computing and visualization. Other NASA assets, such as Earth Observing Satellites (EOS) and Unmanned Aerial Vehicles, (UAVs) also uniquely contribute to creating and managing a sustainable urban environment. For example, UAVs equipped with infrared sensors and information delivery and management systems have proven to be a very effective wildfire-fighting tool. Remote sensing can be used to create topologies of cities and to help understand and mitigate urban heat-island effects.

Sensors collect vast amounts of data representing interactions among the planet's ecosystems everyday. Participants discussed the significant challenges to integrating data from air-borne, space-borne and terrestrial instruments with computer models of climate, ecosystems, and biological systems, and then analyzing and reporting results that can be scaled to the needs of nations and communities. Presenters highlighted several NASA tools for the prediction of environmental change that are needed to develop and deploy effective, useable decision support systems.

Other participants from universities, research institutions, corporations, and a range of public agencies covered topics from home and building energy efficiency, to management of the energy grid, to the comparative assessment of cities from new satellite-based information systems. Home energy management systems have already been implemented in Europe. Next generation, online smart meters provide the real time carbon footprint of household emissions broken down by individual appliance and service. This enables the identification of energy intensive activities and the projection of household savings. This in turn encourages people to conserve energy, an important point considering that energy use accounts for about 85% of household emissions.

A Commitment to Address the Challenges Together

Humanity currently uses the resource equivalent of 1.3 planets to provide for our consumption patterns and to absorb the waste we create. This ecological overshoot has to be corrected if humanity is to have a sustainable future. With more than half of the world's population living in cities, the consumption of energy, food, water, and other essential materials is largely an urban management issue and a major driver in global climate change. An urban research agenda is needed now more than ever and several concepts were advanced.

First, although NASA has an armada of Earth-Observing satellites, there is no mission dedicated to monitoring urban environments worldwide. Two such satellite concepts were proposed during the workshop. First, the NightSat mission is being designed to identify human energy use and distribution through observation of global nighttime light emissions. The satellite will map urban areas to 50-meter resolution to help understand the critical role of urban and industrial activity in the Earth energy, water, and carbon cycles. Secondly, the CitySat mission is being proposed to provide frequent (less than 3-day repeat cycle) of cities world-wide in the visible, near infrared (IR), and thermal IR spectral regions. Its multi-wavelength capability would allow it to identify major land cover classes, study energy use, and study surface energy balances and heat-island effects.

Secondly, the group acknowledged that no federal agency owns the full urban agenda, so research priorities are largely set within a fragmented Federal funding framework. This contributes to a lack of coordination across Federal, State and local regions. There was speculation that NASA might be the best coordinating agency for sustainable urban development, because it has the instruments and satellites to monitor and analyze urban systems along with high-performance computing and remote sensing capabilities. Regardless of assigned responsibility, an organizational structure is required to encourage and coordinate ongoing interaction between decision makers and the science community.

Thirdly, energized by the discussions, the participants committed to continuing the dialogue (virtually and face to face) and pursuing a range of collaborative projects. Some of these will highlight NASA technologies and space-based assets as valuable tools for creating a greener future. Others will build on projects like San Francisco's EcoMap. Underlying most of the ideas, however, is the need to make data useful, sharable by experts for further analysis or converted into data products for decision makers. Whether we want to make better predictions of heat-island effects or monitor energy use to encourage reductions, opportunities for collaboration exist. Communication between NASA and other researchers, city managers, and agency leads needs to be fostered to realize the potential that exists.

Workshop Report On Sustainable Urban Development

Dr. Stephanie Langhoff[1], Dr. Gary Martin[1], Dr. Larry Barone[1], and Dr. Wolfgang Wagener[2]

Ames Research Center

I. Introduction

A workshop entitled "Sustainable Urban Development" was held at Ames Research Center on January 9-10, 2009. This workshop is part of a series of informal weekend workshops initiated and hosted by the Ames Center Director, Dr. Pete Worden. The organizing committee included Stephanie Langhoff (Chair), Gary Martin, and Larry Barone of Ames Research Center and Wolfgang Wagener of Cisco Systems, Inc. The workshop agenda was structured to bring together NASA scientists, city planners, local, state and federal resource agencies, utilities, businesses, and others who are involved in managing aspects of the urban environment. Sixty-seven people representing government, industry, and academia attended (see list of participants).

The key workshop goal was to explore and document how NASA technologies, such as remote sensing, climate modeling, and high-end computing and visualization along with NASA assets such as Earth Observing Satellites (EOS) and Unmanned Aerial Vehicles (UAVs), can contribute to creating and managing a sustainable urban environment. The focus was on the greater Bay Area, but many aspects of the workshop were applicable to urban management at the local, regional, and global scales.

Another goal of the workshop was to help NASA better understand the problems facing urban managers and to make city leaders in the Bay Area more aware of NASA's capabilities. By bringing members of these two groups together, we hope to see the beginnings of new collaborations between NASA and those faced with instituting sustainable urban management in Bay Area cities.

This workshop report summarizes the key points of the many outstanding contributed talks, as well as the key points that surfaced in the World Café style discussions that took place throughout the workshop. The program ended with a discussion of research priorities and follow-on actions.

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[1]NASA Ames Research Center, Moffett Field, California
[2]Cisco Connected Urban Development Group, San Jose, California

Figure 1. NASA Operating Research Missions.

II. NASA's Applied Sciences Program—Objectives and Approach

Dr. Teresa Fryberger began the workshop presentations with an overview of the Applied Earth Sciences effort within NASA. NASA's Earth Science program is focused on studying Earth from space to advance scientific understanding and to meet societal needs. Specific goals are to understand how the Earth system is changing now and how it will change in the future, the cause of these changes, Earth's response to change, and the consequences of these changes for human civilization. As noted by the National Research Council, understanding the complex changing planet on which we live is one of the greatest intellectual challenges facing humanity. Specific elements of NASA's Earth Science program includes building and operating research missions, conducting and sponsoring peer-reviewed research, discovering and developing applications and technologies, making data products available to the science community, and education and public outreach.

NASA already has a fleet of satellites in operation dedicated to Earth Science. In addition, many satellites are planned for the future with a prioritization based on a decadal survey. Dr. Fryberger gave an overview of the satellites that are both planned for the future and that are in operation now (see figure 1). In addition to the Earth Observing System (EOS), there is an airborne and ground-based measurement program within the Earth Science Enterprise to calibrate and validate the satellite measurements and to develop sensors capable of high spatial/temporal resolution to understand small atmospheric and surface structures.

The Earth Science Applications Division's mission is to bridge the gap between the Earth science results and societal needs. The eight program elements include agricultural efficiency, air quality, climate, disaster management, ecological forecasting, public health, water resources, and weather. NASA carries out these programs collaboratively with other federal partners. The program focuses their limited resources on areas that have the greatest impact. In addition, Dr. Fryberger discussed DEVELOP the human capital development program designed for students to demonstrate to community leaders the prototype applications of NASA science measurements and predictions that address local policy issues. In fiscal year 2007, 175 students were in the DEVELOP program, ranging from high school through graduate school. Highlights of the Ames DEVELOP program are discussed later (see Section VII.6).

Dr. Fryberger concluded by noting that NASA's Applied Earth Sciences program contributes to sustainable urban development in many ways, such as monitoring air quality, renewable energy planning, public health, and planning for and responding to impacts of climate change. A number of the follow-on talks in the workshop corroborated these statements and provided further details on research supported under her program.

III. Climate Change - Effects and Adaptation

III.1 Climate Change at the Regional Level

Ed Sheffner, Deputy Director of the Earth Sciences Division at ARC, discussed the current capability of climate models to predict climate change at the regional level. This is the level at which climate change will be experienced and decisions in response to climate change will be made. Therefore, regional climate change is an important element in a sustainable urban development program. He defined climate change as long-term changes in temperature and precipitation, as well as environmental changes in the atmosphere, land, and water that impact life on Earth. Dealing with climate change includes prediction of future temperature/precipitation regimes, mitigation or actions to slow or reverse climate change forcings, and adaptation.

Key questions being addressed by NASA are: (1) how is the global Earth system changing? (2) what are the primary forcings in the system? (3) how does the Earth system respond to natural and human-induced changes? and (4) what are the consequences of these changes to human civilization? Sheffner discussed the ten climate regions that are covered in the International Panel on Climate Change (IPCC) report. The IPCC climate data for North America from 1900-2000 is shown in figure 2 (upper curve is precipitation in millimeters (mm) and the lower curve is temperature in degrees Celsius (°C)). Model predictions indicate a continuation of increasing temperature and precipitation in the 21st century. The predicted increases in temperature throughout the 21st century are expected to significantly reduce Yosemite snow packs. This impacts not only water resources, but also public health, as temperature, precipitation, and snowmelt patterns are major drivers in mosquito abundance and West Nile virus risk.

Sheffner illustrated how NASA satellite data can help regional land management. For example, by combining Terrestrial Observation and Prediction System (TOPS) satellite data with California Irrigation Management Information System (CIMIS) data at various locations, California vintners have improved wine quality by scheduling irrigation to minimize the effects of interannual variability in weather.

A key message in Sheffner's presentation is that NASA has the tools for the prediction of environmental change that is needed to support resource management and policy decisions at the regional level. What is missing is an organizational structure for ongoing interaction between decision makers and the science community. Hopefully this workshop will help establish that dialogue.

III.2 NASA's Contributions in Detecting Urban Heat-Island Effects in Coastal Cities

Dr. Jorge Gonzalez, Professor at the City College of New York, spoke about how NASA's remote sensing and modeling capabilities have helped characterize Urban Heat Islands (UHIs). The UHI effect can be defined as the dome of elevated air temperatures that presides over cities compared with their cooler rural surroundings. He focused the discussion on coastal urban areas, because they depend in a complex way on sea surface conditions, density of urban centers, topography, and sea breeze patterns.

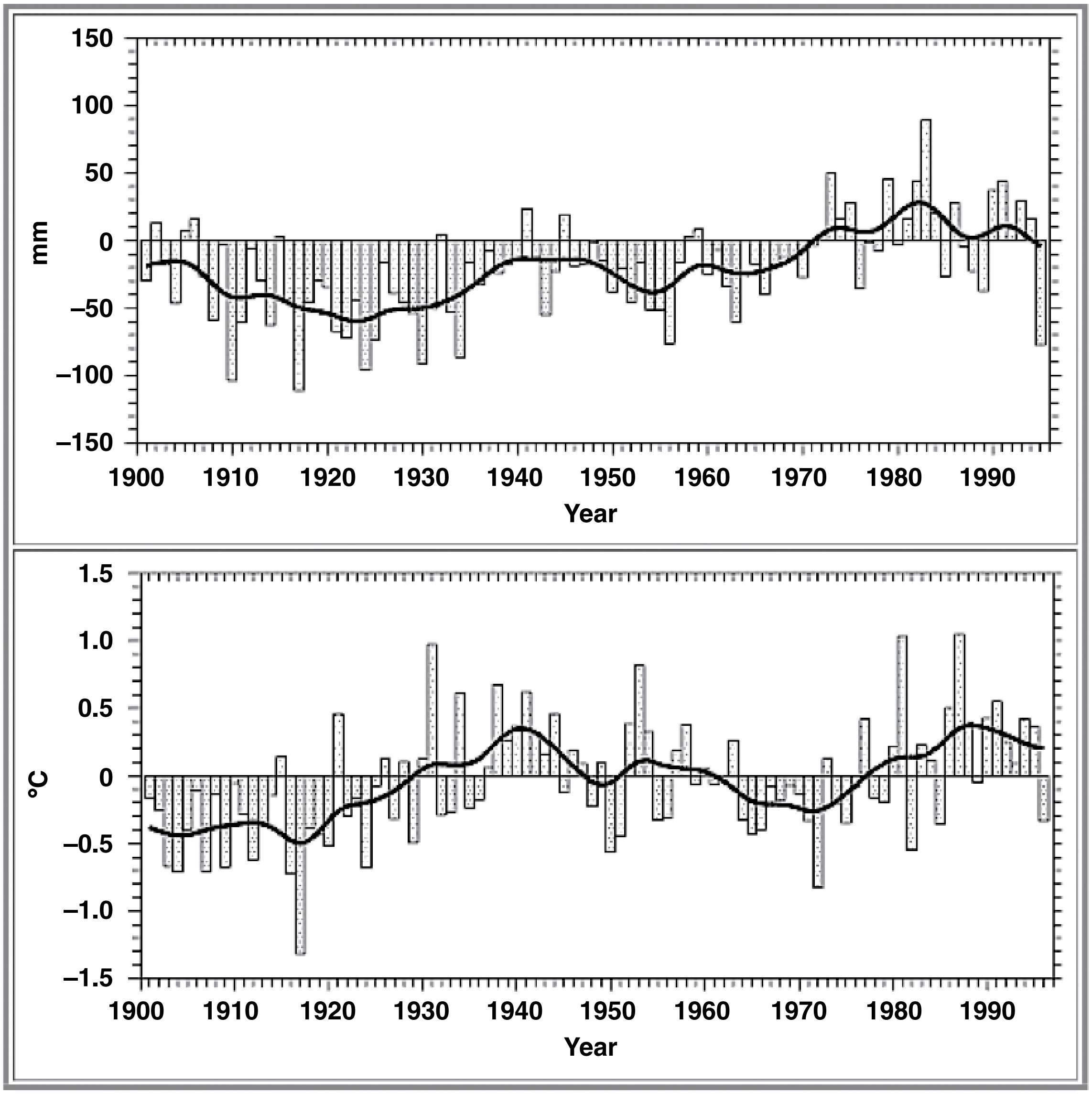


Figure 2. IPCC Climate Data for North America.

The temperatures are elevated over urban areas for a number of reasons. Paved urban surfaces make penetration of precipitation virtually impossible and produce small flash floods over the limited vegetated surfaces. This results in a net loss of water surface area and thus a reduction in cooling from evaporation. In addition, cities have large vertical surfaces of different shapes that affect radiation and wind patterns. Radiation is reflected off the walls resulting in entrapped energy, and wind flow is disrupted creating a reduction in heat loss.

Urban heat islands have a number of adverse effects on the environment and on public health. For example, the increased temperatures lead to poor air quality such as elevated ozone. The UHI effect prolongs heats waves in cities and leads to higher energy usage due to the greater demand for air conditioning. This in turn leads to additional CO_2 production that contributes to global warming. The UHI effect also causes anomalies in precipitation patterns, leading in general to an increase in rainfall over and downwind of cities. Several factors contribute to greater precipitation, such as the increased number of cloud condensation particles in the urban air, the addition of sensible heat from the urban warm air, and increased mixing and turbulence caused by the cities skyline.

Dr. Gonzalez spoke about the capability of NASA airborne and satellite measurements in characterizing UHIs. A key instrument is the Airborne Thermal and Land Applications Sensor (ATLAS) that operates in the visible and infrared spectral regions. It is capable of providing high-resolution images of surface temperatures. He showed how airborne images and ground weather data could be used to identify the presence of a UHI in the urbanized area of San Juan, Puerto Rico. The difference of air temperatures between rural and urban areas corroborate the existence of an increasing UHI for the last 40 years, with predicted differences as high as 8°C for the year 2050. The Regional Atmospheric Model System (RAMS) was used to simulate actual and future scenarios to quantify the impact of urban development in the regional climate of Puerto Rico. To mitigate the increasing UHI effect, he discussed countermeasures such as greening the landscape, using reflective and green roofs, and planning for growth.

In summary, the UHI effect is a clear indicator of anthropogenic induced climate change. Land cover and land use induces changes in the regional climate that impacts surface temperature, flow patterns, and the hydrological cycle. Remote sensors, combined with climate data and modeling tools, are effective in analyzing UHI impacts over coastal metropolitan areas. Finally, mitigation alternatives can be effective in reducing UHI effects.

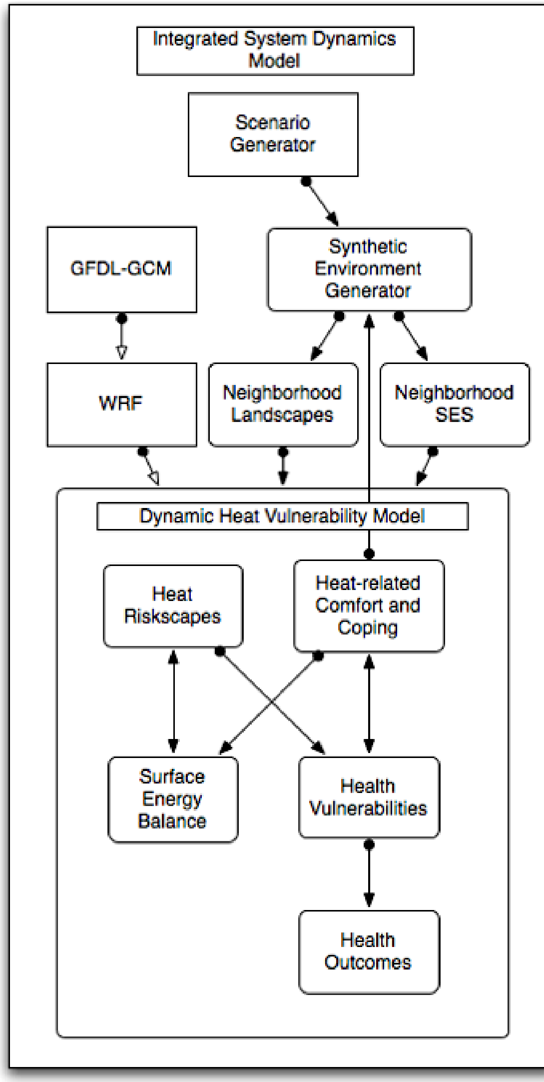
III.3 Urban Vulnerability to Climate Change: A System Dynamics Analysis

Dr. Tim Lant, a Research Director at Arizona State University, presented research on urban vulnerability to climate change using a system dynamics approach. He described a study of the effect of extreme heat on health that took into account social factors in the vulnerability analysis. Landscapes denuded of vegetation in poor neighborhoods expose residents to more extreme heating. Key research questions include how the spatial structure of heat "riskscapes" change with time, and how they are related to changes in urban landscape cover characteristics, climate change, and residential segregation. Another question is how have residentially segregated neighborhoods and heterogeneous "riskscapes" combined to render low-income and racial/ethnic minority populations disproportionately vulnerable to heat-related hazards.

The systems dynamics model shown in figure 3 was used to forecast health vulnerabilities for a given UHI scenario. The model incorporates climate, biophysical, and social data to generate a spatial heat vulnerability model that can predict health vulnerabilities for a given segment of the region. The model helps understand regional societal, vegetation, and climate relationships. Dr. Lant described the results of studies in the Phoenix area, which is particularly vulnerable to UHI effects. He described the "North Desert Village" experiment where residential neighborhoods in Phoenix were landscaped in one of five ways from high-water use vegetation to no plants or water (control). Most residents preferred the water-intensive landscapes for their home. More environmentally conscious residents opted for an oasis-style landscape that minimized turf area, but landscapes that used low water-use exotic and native plants were unpopular.

Dr. Lant showed graphics to demonstrate how the heat island is expanding with time in Phoenix. This has led to an increase in the percent of the population requiring treatment for heat-related issues. Water resources are becoming ever more important in the Phoenix area. He ended his talk by discussing WaterSim, a graphical programming tool that can be used to explore future scenarios of water needs in Central Arizona. The adjustable variables in the model include future water supply projections, climate models, water policies and prices, population projections, and land use options. The model results, which can be displayed in the "Decision Theater" at Arizona State University, will help policymakers participate with the community in collaborative decision making to help achieve a sustainable future.

As part of the discussion following the session, Dr. Steve Hipskind, Chief of the Earth Sciences Division at ARC, gave an overview of the NightSat mission that is being designed to identify human energy use and distribution through observation of global nighttime light emissions. The satellite will map urban areas to 50-meter resolution to help understand the critical role of urban and industrial activity in the Earth energy, water, and carbon cycles. He showed images of Chicago and the San Francisco Bay Area at night. The simulated NightSat resolution is far superior to that currently available through the Defense Meteorological Satellite Program.



WRF = Weather Research and Forecasting
SES = Socioeconomic Status
GFDF-GCM = Geophysical Fluid Dynamics Laboratory General Circulation Model

Figure 3. System Dynamics approach.

IV. Policy Issues

IV.1 Urban Sustainability Initiatives and NASA

Jared Blumenfeld, Director of San Francisco's Department of Environment, discussed the status of the EcoMap implementation in San Francisco. The EcoMap is a geo-mapping based, collaboration, visualization, and measurement tool for citizens, businesses and city authorities. It enables the measurement of carbon emissions aggregated by zip-code, neighborhoods, and at the city-wide scale. As we move from a phase of educating people about climate change to taking actions to mitigate climate impacts, web-based services and smart urban infrastructures enable cities to measure, visualize, and manage the results of community-based climate change actions. An important goal of the EcoMap testbed is to drive social behavior change to improve the key environmental indicators of cities. Two major components of this are transportation and energy consumption. For transportation the goal is to reduce miles driven by encouraging cycling, taking public transit or telecommuting, and by increasing the fuel-efficiency of vehicles. The reduction in energy consumption focuses on reduction through energy efficiencies and an increase in the installation of renewable energy generation.

The EcoMap project is part of the Connected Urban Development (CUD) program that is a partnership of Cisco, the Clinton Global Initiative, and a number of major cities including San Francisco. The program is designed to demonstrate how to reduce carbon emissions by introducing fundamental improvements in the efficiency of the urban infrastructure through information and communications technology (ICT). The availability of a citywide broadband infrastructure is the basis for the successful implementation of CUD. Initially, this will support the development of data, voice, video, and mobile communication platforms that will be used with local and national policy and other efforts to increase enablement of work anywhere/anytime. A second area of infrastructure focus will be the creation of an Internet Protocol (IP)-enabled framework for commercial and business real estate and IP-enabled civil infrastructure that connects roads, railways, gas, electricity, water utility networks, and other city assets such as traffic lights, towers, telephone boxes, etc.

Any discussion of sustainable urban development must acknowledge that ICT is part of the problem facing cities today, based on its ever-increasing levels of energy consumption. This downside, however, is more than mitigated by ICT's valuable contributions to energy efficiency, its ability to reduce energy demand in other activities (e.g., using telecommuting to reduce trips to the office), and the existence of ICT applications that increase the efficiency of energy used in these activities (e.g., car routing that cuts traffic congestion).

IV.2 The Sustainability Challenge: One City's Green Brick Road

Melinda Hamilton, Vice Mayor of Sunnyvale, discussed the city of Sunnyvale's approach to sustainable urban management. She defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." Being "green" is a subset of that concept, recognizing the role of the natural environment in achieving sustainability. While Sunnyvale has a many-faceted sustainability program, she focused on building practices. She described the Moffett Park Specific Plan Area that is located in the northern part of the city.

This plan included incentives for green buildings, including Leadership in Energy and Environmental Design (LEED) certification standards, elements such as employee amenities, a transportation demand management program, alternative fuel vehicle fleets, storm water retention and treatment plans, and wetlands preservation both on and off site. Moffett Towers plan took advantage of those incentives, and as a result, includes a gym, walking trails, and close proximity to light rail. Sunnyvale is in the process of expanding those green building requirements to industrial and commercial zoning in the rest of the city.

In addition to providing incentives for green buildings, Sunnyvale adheres to other green practices. For example, recycling paper, using more energy efficient light bulbs, greening the vehicle fleet with compressed natural gas and hybrid vehicles, using recycled wastewater for landscape irrigation, and burning methane from landfills to power the city's solid waste and recyling center.

The city is a signatory to the U.S. conference of Mayors Climate Protection Agreement, which commits the city to achieving the goals set forth in the Kyoto protocol. In 2007, the city became a pledging partner to Sustainable Silicon Valley's carbon emissions reduction pledge, which requires the city to reduce its carbon emissions by 20% below 1990 levels by 2010. The city is currently at 17% below 1990 levels. In 2006, Mayor Otto Lee formed a mayor's green ribbon task force that leveraged knowledge from individuals and organizations in the city that are concerned about these issues and wanted to contribute their expertise. The city recently hired a full-time sustainability coordinator, to help spread best practices across multiple departments. The biggest challenge is finding the money, especially for the initial costs, with the global credit crisis squeezing sales tax receipts and the threat that the State legislature may take the cities' money to balance its budget.

IV.3 The 2030 Transportation Vision for the Bay Area Region

Dean Chu, a member of the Metropolitan Transportation Commission (MTC), discussed the future of transportation in the San Francisco Bay Area. The MTC draft transportation plan for 2035 is referred to as "Change in Motion", and is available on the MTC web site at http://www.mtc.ca.gov/. It is so called because it is about change and it is about motion. The plan proposes crucial changes to the Bay Area's transportation system. The plan serves to clearly announce that the ways that residents travel around the Bay Area are changing, and that this plan will change them further. By means of its investment choices and adopted policies, the draft transportation plan aims to stimulate the use of public transit, increase the safety, utility and appeal of bicycling and walking, and reduce emissions by private automobiles in the Bay Area, while increasing the efficiency of the roadway systems for all users.

The plan takes several innovative approaches, such as pricing of excess carpool-lane capacity on highways, a transportation climate action campaign to target greenhouse gases, a major public transit expansion program, a multi-pronged freeway performance initiative to maximize throughput on existing highways, and an overall emphasis on measurable performance improvements. The plan itself is a catalog of changes which, taken in their entirety, should lead to a future of greater mobility, reduced congestion, cleaner air, and a better quality of life in the Bay Area. The plan seeks to inspire, innovate and implement an integrated, efficient regional transportation system that bolsters our regional economy, safeguards our environment, and ensures social equity throughout the region.

IV.4 Using Remote Sensing to Coordinate Federal Mission Agency Studies of Urban Systems

Dr. Jonathan Fink, Director of the Global Institute of Sustainability at Arizona State University, spoke about what NASA's role might be in a coordinated Federal mission agency for research concerning urban systems and their impact on remaining undeveloped lands. An urban research agenda is needed now as more than half of the world's population lives in cities. Cities consume most of the energy, food, water, and other essential materials, and are a major driver in global climate change. While National research priorities are largely set by Federal funding patterns, there is no Federal agency that owns the full urban agenda. This results in lack of advocacy and a fragmented Federal urban research program. Figure 4 shows the roles of Federal mission agencies that relate to urban sustainability. No single agency has the role of coordinating urban sustainability research.

Dr. Fink posited that the increasing importance of urban sustainability research and the lack of coordination across federal, state and local regions, presented an opportunity for far better integration. He felt that NASA could play this coordinating role for global urban research for a number of reasons:

- NASA instruments and satellites could measure, monitor, and analyze urban systems
- Remote sensing could be used to integrate urban information
- NASA has the necessary high-performance computing to analyze urban data

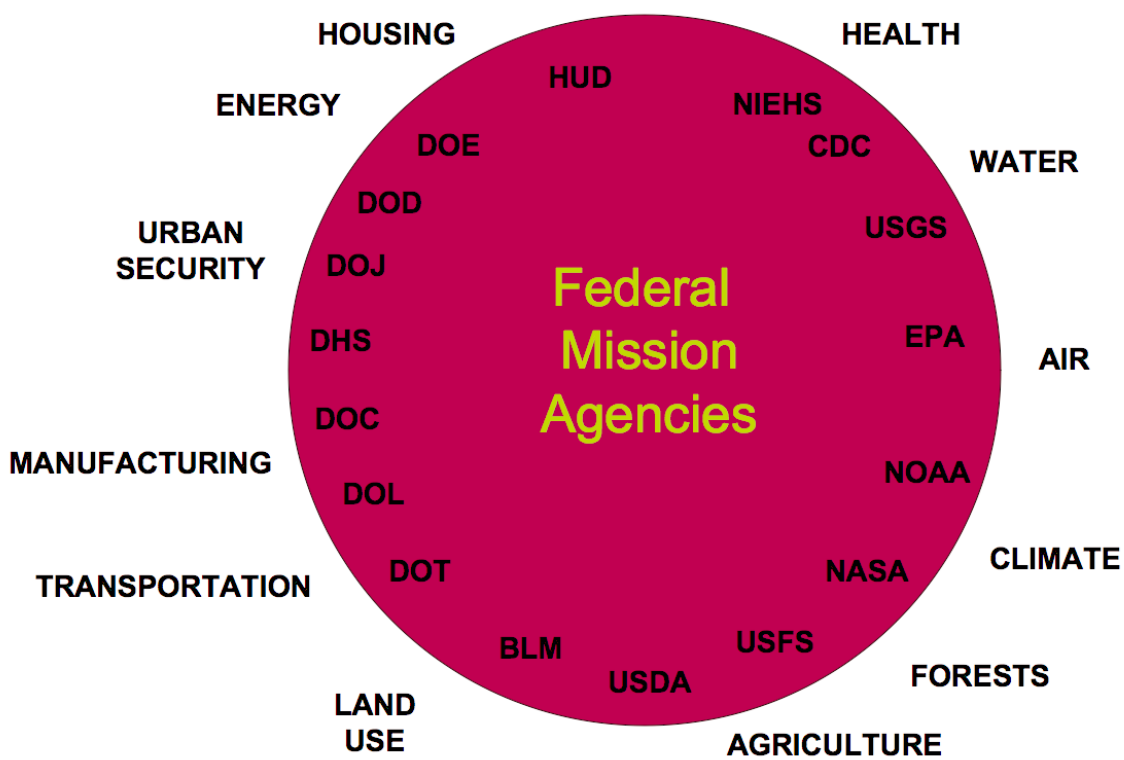


Figure 4. Each Federal agency has a narrow urban focus.

- NASA has broad national presence and is respected worldwide
- NASA could do the necessary coordination at the state and local levels

To realize the potential for NASA in this role would require high-level proposals (e.g., from the National Research Council (NRC) and Office of Science and Technology Policy (OSTP)). Secondly, it would require a road-mapping effort to craft a broad, coordinated Federal urban research and policy agenda, and to explore integrative possibilities. Although this is a bold conjecture, the increasing importance of sustainable urban management calls for action now if we are going to address global warming issues.

IV.5 Integrating Renewable Energy into the Power Grid

Dr. Serdar Uckun, manager of the embedded reasoning area at Palo Alto Research Center, spoke about the challenges of integrating renewable energy into California's power grid. He discussed the legislature that began in 2002 with Senate Bill 1078, which established a Renewables Portfolio Standard (RPS) program requiring 20% renewable energy by 2017. Further energy action plans have accelerated the incorporation of renewables into the portfolio. Just recently in 2008 Governor Schwarzenegger issued an Executive Order requiring 33% renewables by 2020. As shown in figure 5, we are considerably behind schedule on reaching these ambitious 2020 goals. Renewables for urban sustainability include distributed solar, small hydroelectric, tidal or wave generation, wind, biomass, and geothermal. Currently, most of the in-state generation of energy comes from natural gas and nuclear energy. Renewables account for only 11.9% in 2007 compared with 10.9% in 2006.

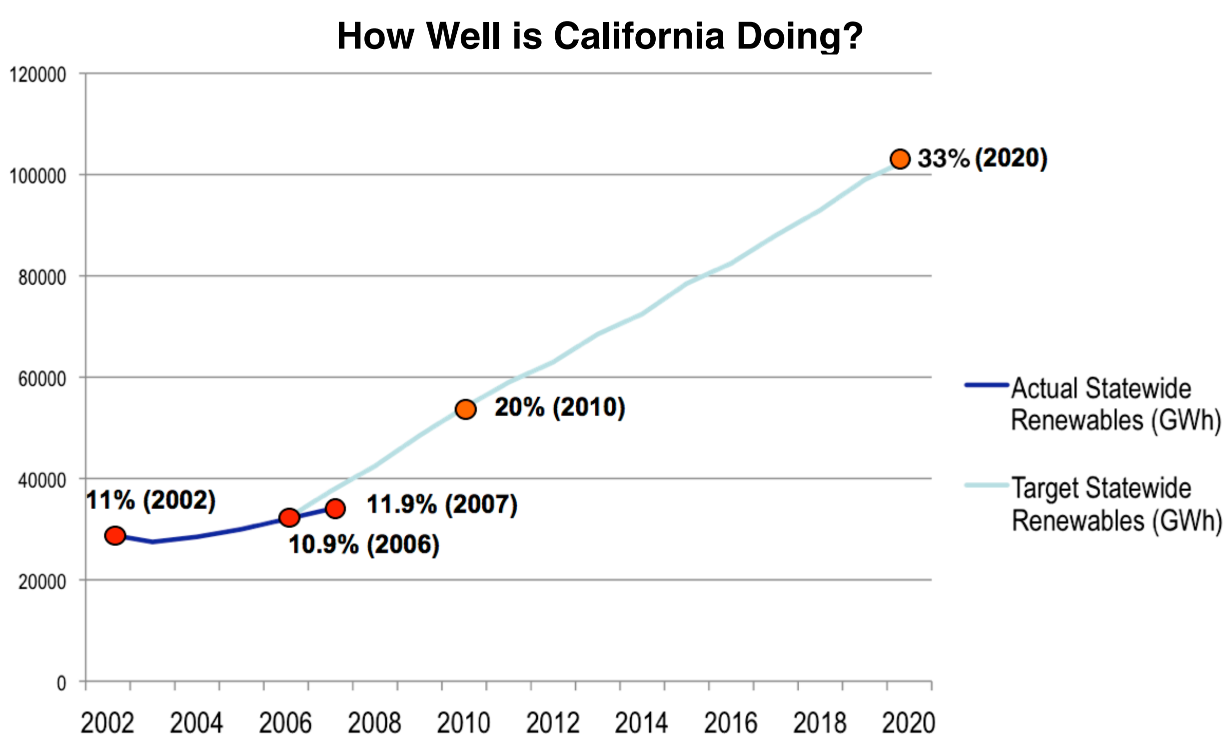


Figure 5. Timeline of California's goal of reaching 33% renewables by 2020.

Managing the power grid requires action on three distinct timescales. On the timescale of seconds to minutes, the power grid must be regulated to handle power fluctuation. On the time scale of tens of minutes to hours, the challenge is to substantially increase or decrease system load (load following). On a daily basis the challenge is scheduling as the daily demand varies. Renewables increase the challenge of managing the grid, because they tend to be more time dependent than more conventional power sources, such as natural gas, coal, and nuclear energy. Wind energy is particularly challenging to predict due to the uncertainty in wind forecasts.

In trying to manage the power grid, both supply side and demand side solutions must be considered. Supply side solutions include spatial diversity (e.g., the output of a wind farm is less variable than a single output unit), using complementary sources (e.g., wind and solar tend to be complementary), better forecasting, and storage. Since the demand tends to be far more variable than the supply, demand side solutions take the form of either reducing electricity use during peak hours or shifting electricity use to off-peak hours. For example, using a “smart” thermostat to raise the temperature a few degrees during peak hours has a significant demand reduction.

V. Urban Sustainability Tools and Modeling

V.1 Humanity's Ecological Footprint

Meredith Stechbart, Project Manager at Global Footprint Network, talked about humanity's Ecological Footprint in a severely resource-constrained future. Key questions include how much regenerative capacity do we use?, how long can we overuse?, and what are the consequences of overuse? She looked at the problem starting from the standpoint of the global system. She noted that of the 51 billion hectares (1 hectare = 10,000 square meters) of surface area on the Earth, only 20% is biologically productive land. The remainder is 67% low productivity ocean, 4% biologically productive ocean (continental shelf area), and 9% deserts, barren land, or icecaps.

To determine the Ecological Footprint, it is necessary to account for all components of the Footprint, namely forest land, grazing land, cropland, built-up land, and fishing ground. It also requires a look at the amount of forested land that would theoretically be needed to store the carbon dioxide emissions created by humanity in that year. The process requires turning resource consumption and waste creation into the associated land area to assimilate that activity. When you add up all the components of the Footprint for all nations of the world, you get humanity's Ecological Footprint. Unfortunately, as shown in figure 6, our current Ecological Footprint is equivalent to about 1.3 Earths. The Ecological Footprint varies significantly across nations. The United Arab Emirates and the United States have the largest Footprint (~9.5 global hectares per person, where a global hectare represents world average land productivity). For comparison, the Ecological Footprint in China is about 2 global hectares per person, compared with the biocapacity of Earth, which is 2.1 global hectares per person. This difference between the global Ecological Footprint (demand) and global biocapacity (supply) is known as overshoot. We need to close this gap between demand and supply if we are to have a sustainable future.

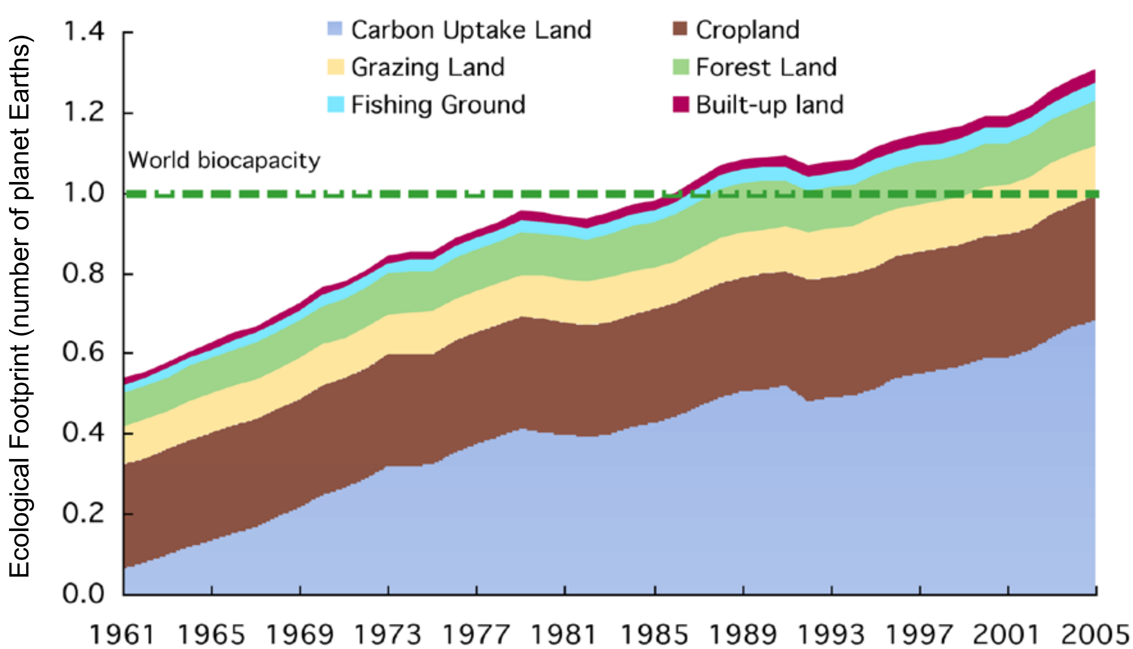


Figure 6. Humanity's Ecological Footprint.

Stechbart discussed briefly an entrepreneurial charity based in the United Kingdom, Bioregional, that is working through its “One Planet Living” program to build practical solutions to enable healthy lives within our fair share of the Earth’s resources. The concept is based on high-density, energy efficient housing that incorporates live-work opportunities to reduce the Footprint of people living in the community. She ended by noting that further information on her organization, Global Footprint Network, and its work to advance the science of sustainability can be found on the Internet at http://www.footprintnetwork.org.

V.2 System Dynamics of Urban Climate, Electricity, and Human Health Issues

Dr. Jonathan Fink presented a contribution from Dr. Jay Golden, Professor in the School of Sustainability at Arizona State University, concerning work of the National Center of Excellence on SMART Innovations at Arizona State University (http://asusmart.com/). The goal of the Center is to provide climate and energy solutions based on sound science and engineering to governments and industries around the world. The Center provides local and regional governments a greater understanding of neighborhoods with enhanced vulnerability to heat-island effects, such as heat-related health problems and power interruptions.

The Center has used the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on the Terra satellite to examine and track 911 calls (equivalent to heat health in Phoenix) in relation to surface kinetics, vegetation, etc. to evaluate how the built environment influences health vulnerability. The Center has carried out an analysis of power outages in Chicago to understand the role that urban morphology (the study of the physical form of a city) has in driving power outages and related health and crime vulnerabilities. NASA satellites are used in these studies, but are augmented with remote sensing from helicopters when the thermal resolution from satellites is not adequate.

High-resolution images of land cover are needed to make substantive material and design recommendations for urban areas. To reduce environmental and human health impacts and improve sustainability requires detailed and vegetated material types of land cover in the models. A repository of the thermal and radiative properties of urban materials is being created to improve the fidelity of the models. Improved accuracy in the models will enable studies of urban climate change, storm water quality, air quality, heat health, and electricity vulnerability, etc.

A new virtual organization called Heat-Waves.org that is working to quantify and reduce the impacts of heat waves was discussed. Their web site (http://heat-waves.org) is designed to bring a national community of researchers together to more effectively track the number of heat related morbidity and mortality incidents, and to explore how regional energy, climate, physical morphology, socio-economic and governmental policies affect the occurrence of these incidents.

The presentation concluded by re-emphasizing several key points. First, there is a great need for a “dedicated” urban satellite with higher resolution. Secondly, existing sustainability models need a much better understanding of the engineered infrastructure and more fine-grained land cover. Finally, there is a growing demand by regional governments to use existing sustainability models to plan future development and to understand the tradeoffs of future scenarios.

V.3 Planetary Skin: Global Distributed Collaborative Decision Engine for an Era of Complexity and Uncertainty

Juan Carlos Castilla-Rubio, Managing Director of the Internet Business Solutions Group (ISBG) Global Climate Change practice at Cisco, discussed the Planetary Skin Project. The project is developing platforms to monitor, authenticate, certify, monetize, and trade carbon flows. The first prototype of the Planetary Skin concept has focused on tropical rainforests. However, the platform is now being extended into other critical biosphere systems—or planetary skin elements—such as water, biodiversity, food production, etc. The platform is a globally distributed collaborative decision making tool developed at Cisco to address a wide range of intractable problems.

The key application of this tool is to address climate change issues. Castilla-Rubio proposed that the six top climate change problems facing humanity are: (1) capturing energy efficiency opportunities; (2) decarbonizing the energy supply; (3) preserving and expanding global carbon sinks; (4) adapting to catastrophic climate change; (5) improving the capabilities of the models for regional predictive Earth Science; and (6) unlocking funding for climate solution deployments. He noted that the cost of doing nothing will be high. Based on 2030 GDP predictions, the cost of a 2-3°C warming is estimated to be between 0.4 and 3.5 trillion dollars. The cost of a "low carbon" economy is affordable, especially if there is no lock-in of a high-carbon infrastructure.

The Planetary Skin platform has the decision making capabilities to manage resources such as energy, water, land, and biomass. The capability of this management tool to address a wide range of environmental issues is shown in figure 7. The integrated risk, resource productivity, and environmental community management capabilities of the software, unlocks multiple applications across public, private, and "people" sectors.

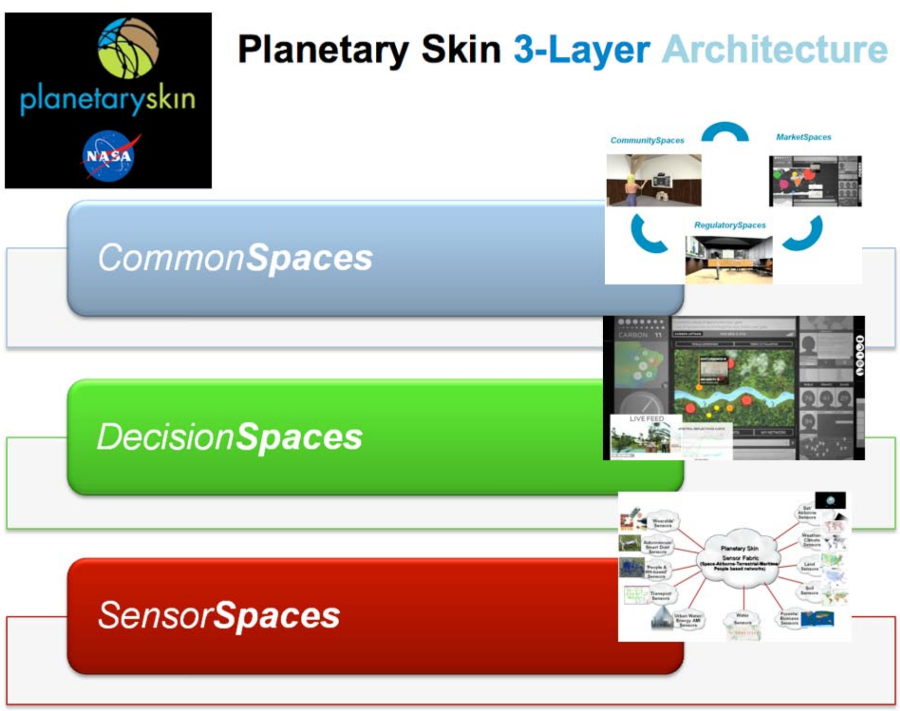


Figure 7. The Planetary Skin platform.

The plug-and-play nature of the Planetary Skin network platform will allow other players in the public and private sectors and in the research and NGO communities to contribute at different layers of the architecture. This process relies on end-to-end transparency, mutual trust, and an unimpeded flow of information across all sectors and institutional borders, on a scale and at a speed that the world has not yet seen.

For the last year or so, Cisco IBSG and NASA have been collaborating to conceptualize, research, and co-develop the strategy and plans underpinning the Planetary Skin initiative. NASA and Cisco IBSG are now embarking on a multiyear R&D public-private partnership to develop pilot programs in preparation for rapid replication and global scaling of Planetary Skin's capabilities.

V.4 Development Strategy Simulator

Dr. Martin Fischer, Professor at Stanford University, discussed his work on platforms for developing good strategical decisions for urban development of a wide variety of urban landscapes in a severely resource constrained world. Who makes these decisions and on what basis? To make correct decisions, accurate environmental, social, and economic input and metrics are required. The best course of action is to build a 4D (3D model plus schedule) development strategy simulator that is integrated, transparent, simple, and visual. The simulator would permit studies of the resilience of various development strategies to changes in scenarios and would take into account the product mix, timing, and the impact of city codes. The output shows the developing 3D shape of the urban landscape as a function of time, with a chart simulation of chosen metrics. A video clip showing a Development Strategy Simulator (DSS) model can be downloaded from http://www.stanford.edu/~fischer/SampleDSSModel.zip. The DSS platform is continually being improved. For example, new infrastructure elements and data are being added. Ecosystem functions are being added to incorporate interactions between the natural and built environment. Efforts are also underway to increase the usability of the simulator, for example, by adding tools and methods for democratic and efficient engagement, and displaying the result in 4D Google Earth. More applications are needed to make the simulator more robust. However, the simulator is being used to improve the development strategies of cities today.

V.5 Geographical Information Systems: Enabling Community-Based Climate Change Actions

Ryan Miller, Technical Lead for the Solar Mapping Initiative at CH2MHill, spoke about how Geographic Information Systems (GISs) enable community-based climate change actions. He noted that Internet GIS systems have transitioned from a niche to mainstream technology with many sites displaying static data. This has greatly reduced the user interface learning curve. The Solar Map Initiative provides a single location on the internet (http://sf.solarmap.org/) to inform the citizens of San Francisco how Polar Voltaic (PV) installations can save them money and reduce CO_2 production. The site provides case studies from a number of locations in San Francisco and provides a comprehensive overview of related resources such as installers, solar rebates, and tax credits. This initiative is part of the overall EcoMap program that addresses the global problem of sustainability at a local scale and allows citizens to compare their progress at the spatial scale of postal codes.

GIS systems have reached the maturity to enable community planning. For example, a user can generate land use/energy consumption scenarios and evaluate long-term outputs. This output can be displayed both spatially and temporally providing a strong visual image to the user. These tools have been well received by the public, but there are still a number of challenges, such as quantifying causal relationships and finding a good "information balance." Opportunities for the future include integrating advanced modeling and simulation tools and using remotely sensed data to develop input for the models. This would help expand the capabilities of GIS to include scenario driven analysis, evaluate "what if" analysis, and optimize the locations of actions.

V.6 Swiss Service Gateway: Creating Internet Services Based on 3D Modeling of the Built Environment of Switzerland

Ludger Hovestadt, Professor at ETH Zurich, spoke about the convergence of information and energy. He discussed the concept of the "Internet of Things," which refers to a wireless and self-configuring network between objects, such as household appliances. If objects can be equipped with radio tags, they could be identified and managed with computers. Housing units or mobile devices could be nodes on the Internet. With electrical devices there is a potential of 30,000 million nodes. Since about 30% of the energy consumption is in mobile devices and 70% in stationary objects (e.g., housing units), it would be possible to track overall energy consumption on the Internet.

Dr. Hovestadt discussed the digitalSTROM Alliance, whose goal is to equip every household with intelligent electrical devices. This technology seeks to achieve greater efficiency in electricity use and greater comfort and functionality by networking electrical devices. There is very little added cost, because the electrical devices communicate using existing power lines. Thus at the local level, these devices could considerably reduce electrical consumption with little infrastructure cost. Dr. Hovestadt also discussed the energy problem from the global view. He noted that the solar area needed to satisfy global energy consumption is relatively small if one could capture all of the incident solar energy. He noted that regenerative energies should become preferred as their production costs drop and the cost of fossil fuels rise.

Dr. Hovestadt ended by noting that while we are talking about a fundamental convergence of energy and consumption, the users must be engaged in the process. He showed a number of efforts in Switzerland to engage the public in trying to reduce energy consumption. For example the Swiss weather channel presents energy stories. Thus, it is not sufficient to just focus on saving energy—we should be creative towards the digital future of energy!

V.7 San Jose's Green Vision: Land Use Policy and Management

Laurel Prevetti, Assistant Director of Planning, Building, and Code Enforcement in San Jose, discussed San Jose's green vision for land use management. The vision for the next 15 years includes spurring job growth, leading in environmental sustainability, and building a model 21st century city. The plan includes the 10 vision goals given below:

1. Create 25,000 clean tech jobs
2. Reduce per capita energy use by 50%
3. Receive 100% of electrical power from clean renewable sources
4. Build/retrofit 50 million square feet of green buildings
5. Divert 100% of the waste from the city's landfill and convert waste to energy
6. Recycle/reuse 100% of wastewater
7. Adopt a General Plan with measurable standards for sustainable development
8. Ensure that 100% of public fleet vehicles run on alternative fuels
9. Plant 100,000 new trees and replace 100% of streetlights with smart, zero-emission lighting
10. Create 100 miles of interconnected trails

She described the current progress that has been made towards these goals. For example, they have created over 2000 clean tech jobs in San Jose, have built over 1 million square feet of third party certified green buildings, and have created over 46 miles of new open trails.

Prevetti discussed the connectivity of the environment, economy, and equity. For example, the challenge of decreasing the electricity and maintenance costs of street lighting results in a policy of replacing traditional lights with more efficient ones. This leads to the creation of new markets such as light-emitting diode innovations and smart communications technologies. This, in turn, spurs new job creation.

Laurel Prevetti ended by speaking about goal #7 above, namely their effort to build a comprehensive land use policy and management tool that builds upon their past sustainability successes. The plan continues to have an emphasis on transit-oriented design and greater density. She described San Jose as a "City of Villages." Future growth needs to take into account the unique characteristics of these villages within the city. In closing, she noted that the City of San Jose's sustainable urban land management program needs to engage the community to build a constituency and create the political will for a long-term sustainable strategy.

VI. Observations and Measurements

VI.1 ARCTAS/CARB 2008: A Collaboration Between NASA and the California Air Resources Board Focused on California Air Quality and Climate

Dr. Hanwant Singh, an atmospheric scientist at NASA Ames Research Center, discussed the Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS) mission, which began as a collaboration with the California Air Resources Board (CARB) to undertake coordinated flights looking at California air quality. Flights were undertaken on NASA's DC-8 and P-3B aircraft. The mission objectives included improving the accuracy and emissions inventory of Green House Gases (GHGs) and aerosols and to relate airborne and satellite observations. The payload consisted of a sun photometer, solar flux radiometer, cloud absorption radiometer, scanning polarimeter, and instruments to measure aerosols, CO_2, and ozone.

The ARCTAS-CARB mission accomplishments were in three general areas. First, the mission provided satellite validation of the measurements taken from the Terra, Aqua, and Aura Earth-observing satellites. Secondly, extensive low-level sampling of emissions across the Southern California Air shed, Central Valley, and offshore shipping lanes provided urban emissions for several population centers, shipping emissions in offshore shipping lanes and harbors, agricultural emissions associated with crops, industrial emissions such as refineries, and natural emissions from oceanic and terrestrial sources. Finally, the mission added to our air quality modeling and prediction capabilities, by providing a complete characterization of aerosols and ozone precursors, and by establishing the boundary conditions for use in California air quality models.

VI.2 CitySat—A Dedicated, Small-Mission Concept for Monitoring Urban Environments Worldwide

Dr. Philip Christensen, Professor in the Department of Geological Science at Arizona State University, discussed CitySat, his mission concept for monitoring urban environments worldwide. CitySat is a small focused mission that provides frequent (less than 3-day repeat cycle) of cities world wide in the visible, near infrared (IR), and thermal IR spectral regions. It takes a small instrument approach using existing low-cost instruments with proven heritage. For example, CitySat would fly a Thermal Emission Spectrometer (TES) that has been proven on the Mars Global Surveyor and the Mars Odyssey missions.

Dr. Christensen felt that the CitySat mission was timely because cities and urban environments were a rapidly growing component of the global climate system, yet no concerted efforts to observe cities were ongoing. The proposal for standardized, repeated urban remote sensing comes out of the 100 Cities Project, a platform to bring policymakers and researchers together to apply urban remote sensing to the problems of urbanization, the environment, and sustainability.

Some of the key science questions that could be addressed with CitySat include assessing the effects that cities have on the local and regional meteorology, climate, air quality, and human and ecosystem health. The satellite would help quantify thermal energy fluxes across the heterogeneous urban surface and lead to a better understanding of how urban land cover affects land-atmosphere interactions. The ability to address a wide range of urban problems comes from its multi-wavelength approach. For example, using visible to near-infrared wavelengths to identify major land cover classes, shortwave infrared to study energy use, and thermal infrared to study surface energy balances and heat-island effects.

To make CitySat a reality would depend on demonstrating that a small (low cost) mission could address critical pieces of the global environmental monitoring problem. Future possibilities for a dedicated urban satellite include a Venture-class mission, a category of highly original and cost-effective satellites designed for a quick development cycle. The CitySat mission fits the mold of Venture Class missions in that it will use experimental technology to demonstrate new research applications or instruments and techniques that provide unique observations.

VI.3 Using Satellite and Climate Models to Study Urban Heat Island and Aerosol Effects

Dr. Menglin Jin, Professor of Meteorology at San Jose State University, discussed the utility that satellites and climate models have in the study of urban heat-island and aerosol effects. Urbanization is an extreme case for land use and land cover change. Her research focuses on using NASA Earth Observing Satellite (EOS) data and the National Center for Atmospheric Research (NCAR) climate model to examine urbanization effects, in particular, urban pollution and urban heat-island effects on climate change.

The Moderate Resolution Imaging Spectroradiometer (MODIS) that flies on the Terra and Aqua satellites views the entire Earth's surface every 1 to 2 days acquiring data in 36 spectral bands. It provides information on land cover, temperature, albedo, vegetation, aerosols, etc. MODIS is playing a vital role in the development of validated, global, interactive Earth system models. The MODIS skin temperatures for Beijing shown in figure 8 clearly demonstrate a significant heat island effect in both the daytime and nighttime. MODIS clearly shows that urbanization affects surface albedo and surface emissivity. Cities are observed to have a consistently higher skin temperature than nearby forests.

Aerosols have both a direct effect of scattering light and an indirect effect of serving as cloud condensation nuclei. Aerosols decrease surface insolation (the amount of solar radiation energy received on a given surface area in a given time). The daily and monthly aerosol observations of MODIS provide the needed data to include the effects of aerosols in the climate models. Dr. Jin discussed the NASA Aerosol Robotic Network (AERONET) sites around the world. This program provides a long-term, continuous and readily accessible public domain database of aerosol optical, microphysical, and radiative properties for aerosol research and characterization. The signature of human activity can be seen in the diurnal and weekly cycle of urban aerosols.

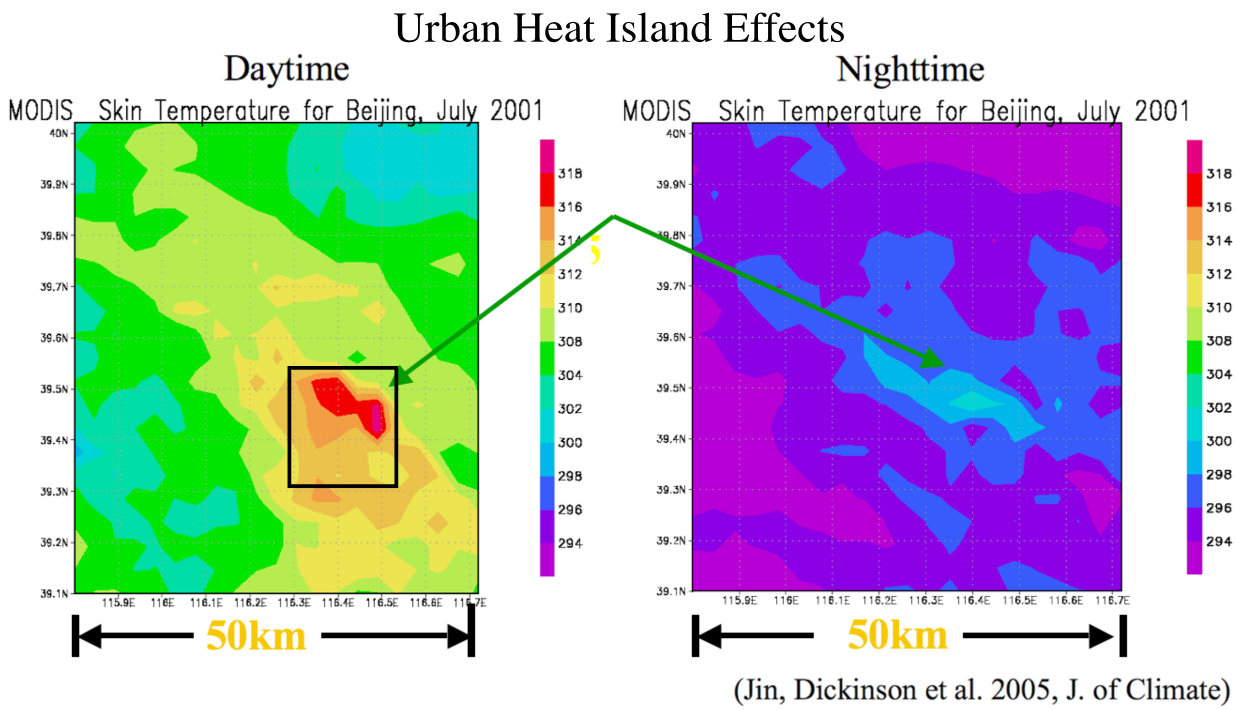


Figure 8. The MODIS skin temperatures for Beijing.

VI.4 Green Shift: Home Energy Management in Manchester and Other European Cities

Vin Sumner, Managing Director, Clicks and Links Ltd, One Manchester Project, spoke about how cities are meeting the challenge of energy efficiency through Information and Communications Technologies (ICTs). The goal is to utilize ICT to enable households and businesses to take action to reduce personal emissions and participate in community action to reduce emissions at a collective level. This requires developing ICTs that are both more energy efficient and that drive new values and behaviors.

Sumner discussed and demonstrated the Digital Environment Home Energy Management System (DEHEMS), a European Union funded project looking at how technology can improve domestic energy efficiency. The aim is to improve the current monitoring approach to levels of energy being used for households, since energy use accounts for about 85% of household emissions. A key factor in the barrier to behavior change in energy use is lack of measurement of emissions impact at the household level. This produces a disconnect between the scale of the problem and the household's role in tackling it. By providing next generation, online smart meters, the real time carbon footprint of household emissions can be broken down by individual appliance and service. This facilitates neighborhood emissions trading that allows households to buy and sell quota according to their "emission budgets." The dashboard that comes with the DEHEMS system allows individual households to monitor both their emissions and energy cost in real time. This enables the identification of energy intensive activities and the projection of household savings. The DEHEMS system is scalable to millions of households. It has an Application Programming Interface (API) for storage and retrieval and for interfacing with other sensor input.

VII. Land Use Management

VII.1 Applied Sustainability: Using a Life Support Systems Approach at NASA Ames Research Center

Dr. Ann Clarke, Chief of the Environmental Services Division at NASA Ames Research Center (ARC), spoke about the sustainability effort that is ongoing at ARC. The Federal definition of environmental "sustainability" is "to create and maintain conditions, in which humans and nature can exist in productive harmony that permit fulfilling the social, economic, and other requirements of present and future generations of Americans." She drew the analogy between the sustainability approach at ARC and the life support system for astronauts. The four strategic focus areas for sustainability at Ames include management and support, direct mission support, protection of mission resources, and proactive risk mitigation. Subtopics in these categories include holding special events like Earth Day, environmental impact analysis and mitigation, clean-up and restoration, and bioremediation and sea level rise. An example of these activities is the environmental impact statement that was developed for the NASA Ames Research Park that lies on government land adjacent to ARC.

Dr. Clarke discussed the proactive efforts at ARC to anticipate and mitigate the effects of climate change, such as sea rise. Some of the effects that are being considered are industrial and storm water flow and pumps, wildlife habitat changes, land area loss, and saltwater intrusion. This has resulted in an effort to work with the Army Corps of Engineers to improve levees in the area and with facilities engineering to place electrical equipment on higher ground.

Time did not permit Sohelia Dianati to present the details of the sustainable land use planning effort at ARC, which is designed to create a highly flexible, collaborative and supportive work environment. Building design is based on the principals of passive and active solar as well as incorporating NASA technology. Cost effective strategies in sustainable Center master planning, building design, and construction meet, and in many cases, exceed U.S. Green Building Council LEED requirements. A conceptual design for such a building is shown in figure 9.

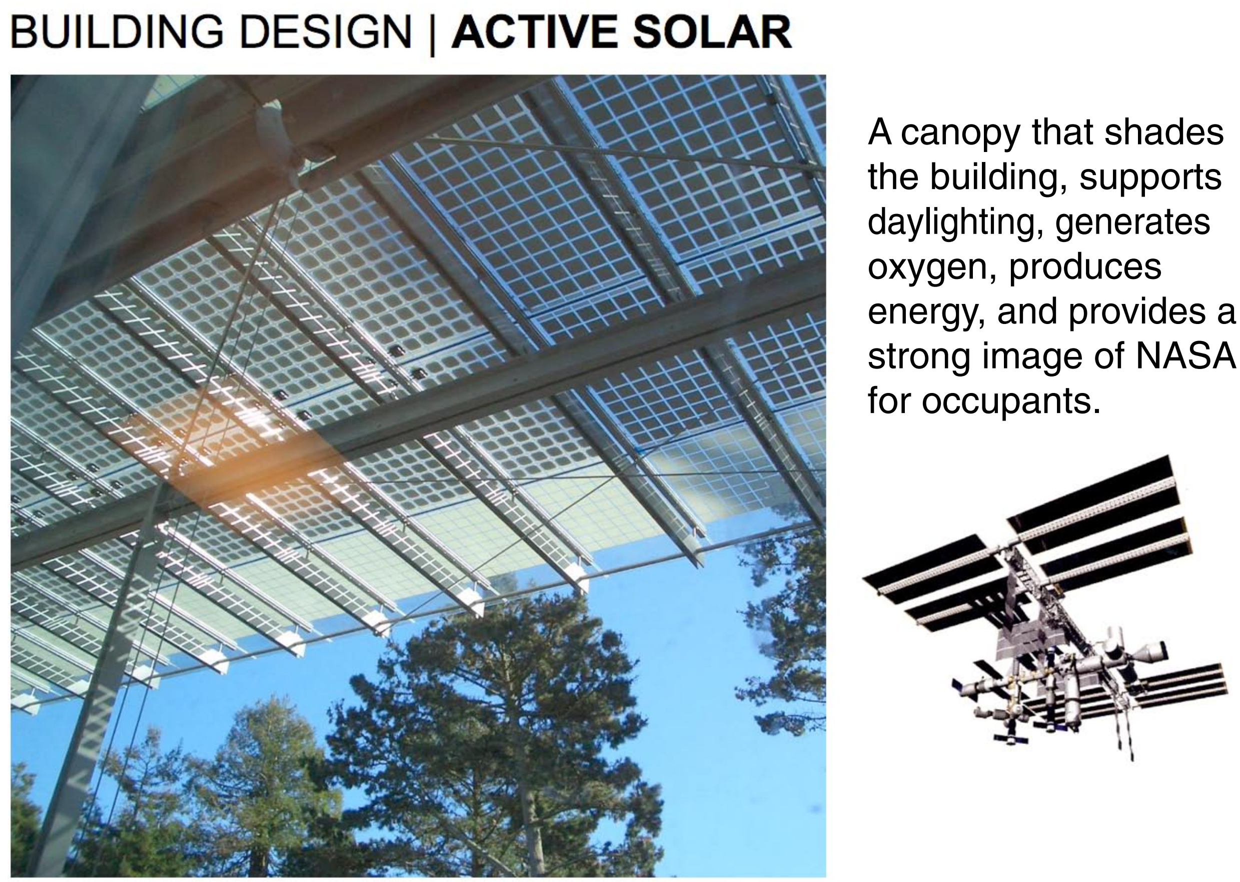


Figure 9. Sustainable building design concept.

VII.2 Better Land Use Planning with NASA Earth Science Data and Models

Dr. Cristina Milesi, a research scientist in the Earth Sciences Division at ARC, spoke about how NASA Earth Science data and modeling capability could improve land use planning. She noted that the built-up area in the United States in the year 2000 was about the size of Ohio. The percent of impervious surfaces increases in urban areas resulting in a higher rate of surface runoff and a lower level of vegetation productivity. A number of options exist for mitigating these impacts of urbanization, such as urban reforestation, green roofing, replacement of asphalt and concrete with permeable surfaces, and restoration of abandoned lands and riparian corridors (the interface between land and a stream).

Dr. Milesi discussed the Terrestrial Observation and Prediction System (TOPS), which is a modeling framework that automatically integrates and preprocesses Earth Observation Satellite (EOS) data from different sources at a variety of spatial and temporal scales. This enables land surface models to be run in both real time and used to generate short and long-term forecasts. In figure 10 we illustrate how combining observations from space-based, air-based, and ground-based assets into ecosystem simulation models can be used to make weather and climate forecasts.

Vegetation productivity is an important variable to monitor over urbanized landscapes. It bears on the recreational and aesthetic value of an urban community, as well as key sustainability issues such as carbon sequestration, emission reduction, and storm water control. Lawns are a major source of vegetation in the United States, representing the single largest irrigated crop in the U.S. For lawns to be a major source of carbon sequestration, a high level of resource inputs (water, fertilizer, etc.) is required. Since the irrigation of lawns is a major use of water, urban growth increases regional outdoor water consumption. Climate change that affects temperature, precipitation, and the growing season length can also increase urban outdoor water consumption. This makes water management an important issue in many parts of the United States.

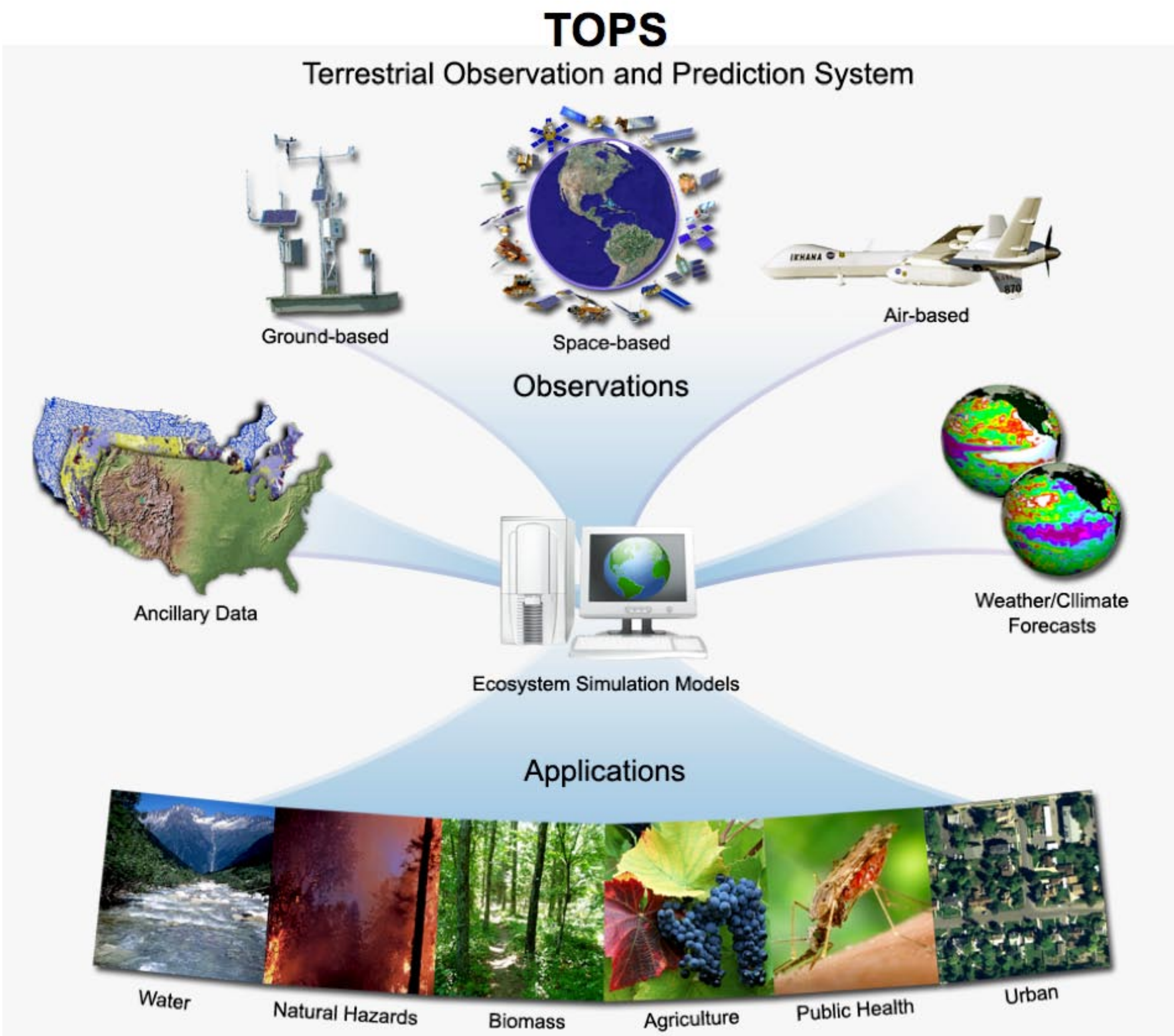


Figure 10. An illustration on how combining observations from space-based, air-based, and ground-based assets into ecosystem simulation models can be used to make weather and climate forecasts.

VII.3 NASA Science Serving Society: Improving Capabilities for Fire Characterization to Effect Reduction in Disaster Losses

Vince Ambrosia, a research scientist in the Earth Sciences Division at ARC, spoke about the state-of-the-art in fire characterization. He started by emphasizing that the most-critical element of effective disaster management is the delivery and ease of use of timely data. This requires the development of effective collaborations. He discussed the Wildfire Research and Applications Partnership (WRAP), which is funded collaboratively between NASA and the U.S. Forest Service. The objectives include exploring, developing, demonstrating, and transferring NASA capabilities to the USFS, the National Interagency Fire Center, and other partner fire management agencies. The major capabilities that had to be developed to achieve an effective firefighting tool included long-duration aerial platforms, improved infrared sensors, and information delivery and management systems.

The key aerial platform used to demonstrate these technologies is the NASA Ikhana, a derivative of the Predator B (MQ-9). The vehicle is capable of high-altitude operations for 24-hour periods, and of autonomous payload operations and real-time sensor data delivery to anywhere in the world via an onboard satellite communications system. Another key in developing an effective tool for fighting wildfires is the Collaborative Decision Environment (CDE) data visualization tool with geographical data displayed in GoogleEarth. The information presented in this application provides an accurate near-time picture of the current fire situation. It has external links to weather, critical airspace information, and MODIS data that provides hot spot fire detection data.

Ambrosia showed the application of the system to support the southern California wildfires of October 2007. The Ikhana flew four missions totaling 32 hours and delivered real-time data to fire incident command centers and county and city emergency operations centers. This allowed tactical decisions to be made regarding approaches to fighting the fire and assessment of areas at immediate risk, allowing effective mitigation strategies and evacuation. This is an example of how NASA is leveraging its scientific and engineering expertise to minimize disaster impacts by saving valuable time, resources, and property.

VII.4 Mountain View's Sustainability Vision

Margaret Abe-Koga, Mayor of the City of Mountain View, discussed her city's sustainability vision. Sustainable development is defined as one that meets the needs of the present without compromising the ability of future generations to meet their own needs. The process began with the creation of an environmental sustainability task force composed of interested city residents. They were tasked with recommending achievable short-term and long-term community-wide actions to reduce greenhouse emissions and create a sustainable environment. The goal was to exceed California's requirements for emission reduction. After receiving the task force's recommendations, the Mountain View City Council created a Council Environmental Sustainability Committee (CESC) to analyze the recommendations. The city is currently in the process of hiring a sustainability coordinator. At the recommendation of the CESC, interested community members have formed a new citizen-led group called the "Green Mountain View" citizens group to work with the CESC and the City Council to implement the recommendations. Every effort at community outreach has been made down to getting the input of school children.

Sustainability and stewardship is one of the 12 planning principles that the City Council of Mountain View employs in the decision making process. Furthermore, in the vision for the future it states, "the City of Mountain View embraces sustainable living." Mayor Abe-Koga discussed a sampling of past and current actions related to sustainability. These include installing solar power in the downtown parking garage, hybrid and bio-diesel fleet growth, energy conservation, and landfill gas conversion to electricity. They have passed ordinances for recycled water, water conservation landscaping, and the handling of construction and demolition debris. The city has won awards for solar installation, urban reforestation, and transit-oriented development. However, what is most impressive is the degree to which they have engaged the citizens of Mountain View in the process. In their Environmental Sustainability Task Force they had more than 65 community volunteers working over 7 months on 20 steering committees to produce 89 recommendations in a 301 page report.

VII.5 Using Remote Sensing to Facilitate and Accelerate a World-Wide Urban Sustainability Collaboration

Harris Tiddens, Vice President at T-Systems Enterprise Services, spoke about how remote sensing could be used to accelerate a world-wide urban sustainability collaboration. Cities presently harbor half of the world population and have many common characteristics, yet cooperation between cities is minimal. Remote sensing could help cities with commonality learn from each other's best practices. For example, remote sensing could be used to create topologies of cities based on their geomorphological and meteorological properties, and capture these in standardized sets of sustainability parameters. This would enable cities to find their peers on a global basis and help them define their sustainability objectives. This focus on cities is justified because they produce a very large fraction of the world's Gross Domestic Product (GDP). According to the World Bank Development Report, about 90% of the GDP is produced on just 16% of the land area. While National states are quite different, cities are more alike than different, despite their complex individuality.

Tiddens contended that cities are complex adaptive systems that have comparable properties and behavior. The success in the global sustainability challenge depends on the success of the world's cities to develop good sustainable behavior. He noted the resemblance of urban sustainability care to human health care. Remote sensing can deliver detailed time dependent information on climate, water, geomorphology, the urban landscape, traffic, energy loss, and basic emissions. Thus remote sensing is the logical starting point to facilitate a worldwide urban sustainability collaboration. Possible next steps include defining the remote sensing techniques to economically deal with 9000 cities. Then conduct an international trial study with some 120 cities from across the world. Cities would then be able to identify their urban peers and work together to develop best practices for urban sustainability.

VII.6 DEVELOP Internship Program for Earth Science

Dr. Jay Skiles, a research scientist in the Earth Sciences Division at ARC, discussed the DEVELOP program, which is a human capital development program funded by the Applied Sciences Program within the Earth Sciences Division at NASA Headquarters (http://develop.larc.nasa.gov/). DEVELOP projects relate directly to applications in agriculture, air quality, disaster management, ecological forecasting, public health, water resources, and weather. The program started in 1998 at Langley Research Center and was expanded to ARC in 2003. The objectives of the program include giving students an understanding of NASA applied science capabilities, such as remote sensing, geographical information systems, and data visualization applications, as well as how to use NASA data to address a community issue. The program helps demonstrate the importance of applied sciences technology to localities through outreach of pilot projects.

Dr. Skiles illustrated the program by discussing two recent projects. He first discussed the project to investigate the correlations between satellite-derived aerosol optical depth and ground measurements in California's San Joaquin Valley. The main sources of pollution are local agriculture, atmospheric drift, and automobile exhaust. Consequences include local and regional public health disparities and an altered radiation budget. The study led to improved correlations between satellite and ground measurements, which will lead to more effective regulation of air quality, and subsequently cleaner air and a reduced health risk.

Dr. Skiles also discussed a project to identify the spread of the West Nile Virus in Monterey County, CA. The goals of this project were to identify the habitat of competent mosquito vectors, to correlate vector habitat with vulnerable population, and to create a risk map for infection. The strategy was to identify the most likely regional mosquito vectors and vulnerable hosts, and to conduct fieldwork sampling mosquito larvae and vegetation classification using satellite imagery. This input was then used to do a geographical information systems analysis to obtain a West Nile Virus mosquito risk map as shown in figure 11. High-risk areas were found to be associated with water environments, in part, because birds were the principal hosts for spreading the disease. The interns presented the results of their study to the Monterey County Board of Supervisors. Thus the DEVELOP program carries out not only its objective of educating students about the capabilities of applied Earth science, but also produces information of significant value to local communities.

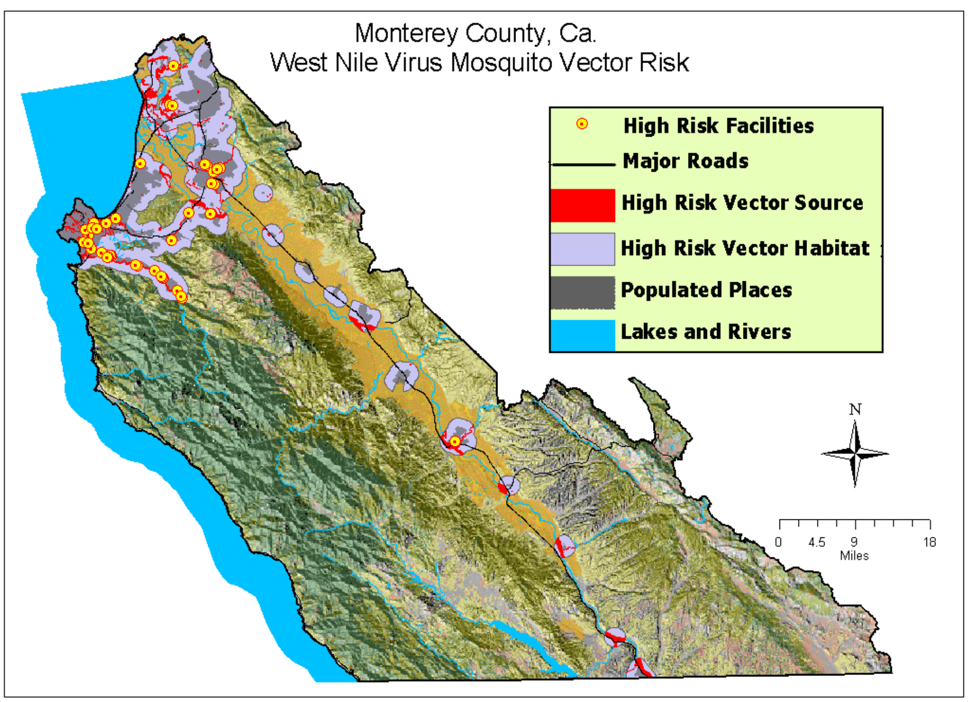


Figure 11. West Nile virus mosquito risk vector map for Monterey County, CA

VIII. Water Resources and Air Quality Issues

VIII.1 Remote Sensing and Modeling of Carbon and Hydrologic Fluxes in Urbanized Watersheds

Dr. Chris Potter, a research scientist in the Earth Sciences Division at ARC, discussed a global simulation model that combines satellite, climate, and other land surface databases to estimate biosphere-atmosphere exchange of energy, water, and trace gases from plants and soils. The model simulates the fluxes of all major biogenic "greenhouse" gases and reactive tropospheric gases. The model has significant capabilities for carbon management. For example, to determine the location and magnitude of biomass fuels that are susceptible to burning, to monitor the health of urban parkland vegetation, to estimate the net greenhouse gas (H_2O, CO_2, CH_4, N_2O) production, and to estimate the carbon sink potential of urban vegetation cover, including effects of future climate change.

Dr. Potter next discussed the United States Department of Agriculture (USDA) Soil and Water Assessment Tool (SWAT) tool. SWAT is a river basin scale model developed to quantify the impact of land measurement practices in large, complex watersheds. He discussed how the model was used to study water quality issues in the Laguna de Santa Rosa watershed. The watershed has been significantly impaired over recent years as natural land cover has been urbanized and converted to agricultural uses. The Geographical Information Systems (GIS)-based SWAT model readily accepts updated remotely sensed layers, land cover, climate, and soil file inputs. The model predicts the transport of constituents into and out of all sub-basins and river channels. The model can be used to make predictions of the impacts of drought or climate change on surface water yields and demands, as well as the effects of land cover and land use change on surface water transport of non-point source pollutants. It can be used to monitor the production of ex-urban "ranchland" and the demands for supplemental irrigation water and to monitor the effects of the spread of invasive plant species.

VIII.2 The Effects of Climate Change on Emissions and Ozone in Central California

Dr. Su-Tzai Soong, a member of the Bay Area Air Quality Management District, discussed the effects of climate change on emissions and ozone. Key questions that were addressed were what would be the effect of predicted temperature increases on emissions and on ozone levels? To answer these questions requires both numerical modeling and observational data verification. He discussed a high ozone event between July 31 and August 2, 2000, captured during the Central California Ozone Study. Observations were taken in the San Francisco bay, Sacramento, and San Joaquin Valley areas. The predicted increase in Biogenic Volatile Organic Compounds (BVOC) varied from 15-19% for a 2°C temperature increase. Both the increase in temperature and the BVOC emissions play major roles in the regional photochemical production of ozone. The predicted increase of the maximum 8-hour ozone in the San Francisco Bay Area because of a 2°C temperature increase and the associated increase in BVOC emissions was 9 ppb. This increase in ozone will offset about 15 years of efforts in reducing the ozone in the Bay Area. A similar

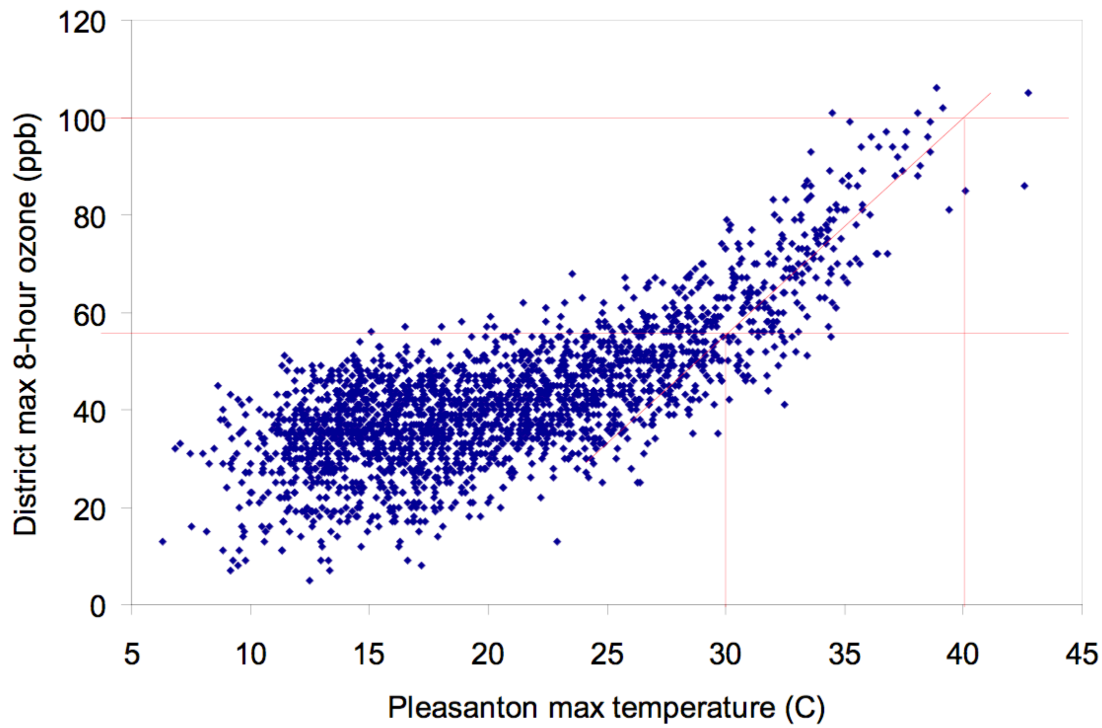


Figure 12. Observed ozone and temperature.

strong correlation between ozone concentration and temperature was observed, as demonstrated in figure 12, in which the temperature at Pleasanton was used as the representative temperature for the Bay Area during high ozone days.

VIII.3 Water Use Challenges in Santa Clara Valley

Dr. Hossein Ashktorab, the water use efficiency unit manager at the Santa Clara Valley Water District, discussed the water use challenges facing the Santa Clara Valley. The mission of the water district is to provide a healthy, safe and enhanced quality of living in Santa Clara County through watershed stewardship and comprehensive management of water resources in a practical, cost-effective and environmentally sensitive manner. Santa Clara County is a semi-arid region with rapid population growth. The breakout shown in figure 13 illustrates the diverse and flexible water supply portfolio for Santa Clara County. He noted that local rainfall, snow pack, and reservoir levels were all below normal for this time of year. The water district is currently calling for a voluntary 10% reduction in water usage, but if drought conditions persist, mandatory water restrictions may be required. Note: at the time of this printing, the water district is calling for mandatory 15% water conservation.

The three key components of Santa Clara's water use efficiency program are conservation, recycling, and desalination. Due in part to water use efficiency efforts, water use in the Santa Clara County has not increased significantly over the last 30 years despite the increase in the region's population. Water use efficiency not only saves water, but has water supply management, environmental, and energy savings and air quality benefits as well.

Dr. Ashktorab also discussed the district's recycled water and desalination programs. Recycled water uses include agriculture, golf courses, cooling, and decorative fountains. The advanced treatment technologies for improving recycled water quality include tertiary treatment, micro-filtration, and reverse osmosis. These technologies are needed to enhance recycled water and reduce micro-contaminants and salinity. Water quality improvements increase the potential uses of non-potable recycled water such as for stream flow augmentation. It is timely to implement advanced treatment technologies, because of the long lead time required for groundwater recharge reuse projects. The stumbling blocks to solving water recycling and desalination challenges are the infrastructure and energy costs, gaining public acceptance, and coordinating multiple political entities.

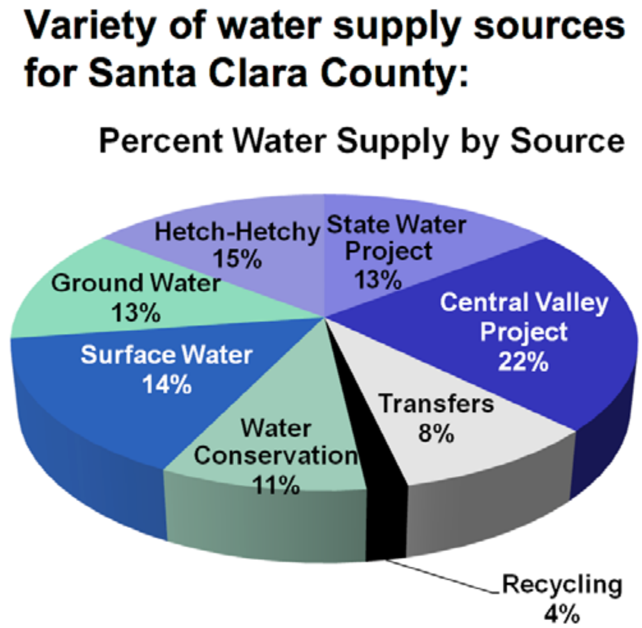


Figure 13. The diverse and flexible water supply portfolio for Santa Clara County.

VIII.4 Low Cost, Scalable, Water Clarification

Dr. Meng Lean, a principal scientist and area manager at the Palo Alto Research Center (PARC), discussed a new technology approach to water clarification. There are three key elements to the clean water technology program at PARC. The first element is hydrodynamic separation without a physical barrier designed to separate particles down to 1-3 microns in size. The second element is a spiral mixer that produces effective turbulent mixing and a custom shear rate to produce a dense, uniform-sized floc. The third element is an in-line coagulation, flocculation (a process where a solute comes out of solution in the form of floc or flakes), and separation process that reduces the process time down from hours to minutes.

While the principal focus is municipal water treatment, the process has many other water applications, as well as other application areas that benefit from being able to separate particles from a moving fluid. The PARC technology developments seek to replace the flocculation and sedimentation steps in conventional water treatment plants, and thereby reduce both the cost and process time. A key innovation in this approach is the spiral mixer that promotes rapid mixing and accelerated aggregation kinetics because of the uniform-sized floc that it produces. PARC estimates that this new technology produces a 34% capital cost savings, a 30% maintenance cost savings, and a 58% space savings compared with conventional and membrane treatments. Laboratory operating prototypes currently have process speeds varying from milliliter/minute to 100 liter/minute.

IX. World Café Discussion—Key Points

Except for clarifying questions, the discussion time was organized into three World Café sessions. The World Café is a discussion/dialog process that takes place in small groups within the larger group. Questions are developed of a sufficient general nature so that everyone can participate in the discussion. Participants rotate between the small groups, building upon former discussions. The World Café approach was used in part due to the very diverse nature of the workshop participants that included both users and developers of technology. Café conversation is designed to foster collaborative dialogue, active engagement, and constructive possibilities for action. The discussion style tries to incorporate the following six guidelines: clarify the purpose, create a hospitable space, explore questions that matter, encourage everyone's contribution, connect diverse perspectives, and listen for insights and share discoveries. More information about the World Café is available at http://www.theworldcafe.com/articles/cafetogo.pdf.

The initial questions that were proposed to the participants in the first round of the "World Café" were "what would constitute success of sustainable urban management from the standpoint of NASA, academia, and the communities and cities?" and "what ideas and thoughts have you heard at the workshop that might contribute to this success." One of the key comments that came out of this first round was that there is a lack of communication across agencies and organizations. There is no national or federal effort or ownership to deal with urban management. Should NASA be that agency? Some commented that the effort of the San Francisco Department of Environment to provide information on city efforts to reduce pollution, promote recycling, and improve the environment, was a good model that could be used in other cities. In other words, we should extend the urban EcoMap concept that is currently being developed within the city of San Francisco to other cities. It was noted that using zip codes or census areas to track progress in urban management was a proper approach that avoided most privacy issues. One could then use zip code competitiveness to motivate participation. There were comments to the effect that both technology improvements and changes in people's behavior will be needed to make progress in sustainability.

In the second and third rounds, the questions proposed included, "what are some of the information and data gaps that we could close with technology, and what measurements should we be undertaking?" Also "how can we improve communication and collaboration?" Suggestions that came out of these rounds included launching cheap satellites to collect urban data. However, we need to establish what data is needed, define a common platform to merge data sets, and establish a means of using the data to make reliable decisions regarding sustainability. In doing so we need to be aware of the global effects of our actions to prevent unintended negative impacts.

There was considerable discussion on how we could change people's behavior to encourage a more sustainable lifestyle. Taxing is one mechanism, for example, on carbon, trash cans, miles driven, etc. Financial incentives may have limited utility if only focused on energy efficiency. The metrics must be more comprehensive if we are to consider all of the factors affecting "residential health", such as toxicity and indoor air quality. Possible metrics might include habitat restoration, vehicle miles driven, and the increase in Riparian corridors. Ultimately, we need to make clean renewable energy affordable to the masses to make these technologies common place.

Many felt that developing and managing an intelligent collaboration is difficult. An overall plan is required with metrics for success. Greater collaboration is needed between federal, state, and local governments. One idea is to pattern the effort after the collaboration between NASA, the U.S. Forest Service, and local communities in fighting forest fires. It would be desirable if cities would collaborate directly on relevant sustainability issues. An analogy between cities as systems was drawn to how health care views patients.

Communication is a challenge in part because scientific culture is a barrier to the free flow of information. Technologists and decision makers need to be willing to invest the time to learn how to communicate and interact. Many felt bringing together diverse groups such as in the present workshop was a good start. Other ideas for enhancing communication included short and long courses, professional development programs, certification, embedding people in opposite fields, and a NASA sabbatical program. We should develop a business model for how we would improve communication and collaboration.

What would constitute success at sustainable urban management from the standpoint of NASA, academia, and the communities and cities? For cities getting a dedicated satellite in place (e.g., CitySat), which combined with sub-orbital and ground-based measurements would give cities a better understanding of the contributions to their carbon footprint, would be a sign of success. Cities would then be better able to separate the contribution from infrastructure, fabrication, and the transportation of people and goods. It would also help cities deal with pollution mitigation. From an academic standpoint, there needs to be funding opportunities to address the fundamental science and to train students to deal with the mounting problem of global warming. As demonstrated in the workshop, NASA can contribute both data and technology solutions. However, there are challenges in being able to sustain the measurements over time to establish a long-term record of climate. If NASA is to influence climate change studies, it must supply high-quality spectral data continuously.

The late afternoon World Café that followed the "urban sustainability tools and modeling" session dealt with issues such as how the science community can transfer the technologies and modeling capabilities they have developed to potential users. For example, to city managers trying to incorporate sustainability into their vision for the future. Can we put the models into a form like SimCity that are easy to use? We also need to develop the metadata for the models and obtain more precise data within cities. The frequency at which data is acquired and/or verified needs to be determined. Real-time data at the household level would help us to understand energy flux in buildings to make models more robust. The science community should develop the instrumentation to monitor the footprint of cities, e.g., permanent observing stations to monitor aerosols, boundary layers, and incident radiation. Useful information about cities could also be obtained by using aircraft equipped with infrared sensors and spectrometers. Cities are often not good at managing sustainability. Would benchmark organized standards help? Cities should become more self conscious and use remote sensing to assess themselves. It was suggested that we should work to combine our knowledge of heat islands with Fischer-like 4D models.

There was considerable discussion about the need to develop a sustainability engineering management plan. A process is needed that integrates all relevant areas into a system that can be evaluated with respect to sustainability. Since sustainability is difficult to quantify, the process should include a mechanism that continuously redefines what sustainability means. The plan needs to be open to all to allow communication and feedback. There needs to be a long-term, global-scale research program that incorporates assessment with mitigation approaches. We must take a global perspective that includes all stakeholders, even though actions are enacted locally.

What are the opportunities for future collaboration? One that has already been mentioned is implementing the SF EcoMap project in other cities. A key challenge is getting the data products from NASA into a GIS friendly format that cities can use for planning. NASA needs to continue its global ecosystem studies and continue to develop models that can forecast climate changes at the regional/local level. Also, to model urban heat-island effects in cities it would be desirable to have detailed 3D spatial information about the city, including buildings, vegetation, and lakes. This would enable better predictions of heat-island effects as a function of incident solar radiation, temperature, and wind direction. While there are clearly significant opportunities for collaboration between NASA and city managers, communication needs to be improved to realize the potential that exists.

X. Final Comments and Future Directions

The Sustainable Urban Development Workshop provided city leaders and policy makers, entrepreneurs and business leaders, research scientists and managers an opportunity to share their own perspectives and challenges, and more importantly, discuss possible collaborative opportunities. The presentations helped participants better understand the problems facing urban managers and city leaders in the Bay Area and explored ideas about how NASA capabilities can contribute to creating and managing a sustainable urban environment – the twin goals of the workshop. The three World Café sessions stimulated thinking about ways to better address these local challenges, as well as expand and spread such approaches globally.

By combining short, conference like presentations with extensive, structured discussion time, the workshop targeted identifying future action over reporting on current activities. Participants agreed that NASA could provide an extremely valuable arsenal of tools to better address sustainable urban development challenges. They also readily identified the major challenges to effectively leverage and amplify these assets. Remote sensing, climate modeling, high-end computing, satellites, unmanned aerial vehicles, and other NASA assets and capabilities can contribute significant horsepower when collecting and analyzing the data needed to make good, urban development decisions. Limited funding, the lack of federal coordination and communication between agencies and organizations, the flood of information and data, and effectively applying such information to change behavior at local levels, however, are but a few of the major hurdles we face. The most viable way to leverage such assets while addressing these challenges is through increased collaboration.

While several specific project concepts emerged from these discussions (such as creating a City Sat; replicating San Francisco's EcoMap; or improving the visualization of heat-island effects), three underlying themes emerged as the foundation for future, collaborative activity:

- Build community. In the absence of a coordinated federal program, the participants urged organizing further workshops and adopting Web 2.0 tools (e.g. wikis) to spur further communication and community building. Such cross sector, multi-interest group gatherings and exchanges are necessary to build the network, spread and cross-pollinate viable ideas and solutions.

- Improve access to and the usefulness of scientifically sound information. More accurate information on land cover classes, energy use, surface energy balances and urban heat-island effects are needed, but such information must be more broadly provided through useful systems – to the researcher, land manager and business leader.

- Emphasize action-oriented, behavior change projects. Ultimately, future efforts are aimed at changing people's behavior. Projects need to focus on creating such change locally, assessing their effectiveness, improving results, then spreading programs globally.

As demonstrated in the presentations made by representatives from the cities of San Francisco, San Jose, Sunnyvale, and Mountain View, local municipal governments are making a strong commitment to urban sustainability by formulating a range of programs, shaping land-use policy and creating sustainability-focused departments and commissions. California State and district agencies are crafting regulatory systems typically more advanced and demanding than their Federal counterparts (stricter green house gas emission standards, water conservation programs, traffic and congestion management, etc). Corporate leaders are setting their own internal carbon-footprint reduction goals and developing shared infrastructure and systems to support regional efforts. Entrepreneurs are developing new alternative energy sources, technologies and tools to help conserve energy use and monitor our households and workplaces. Research scientists are monitoring, modeling and studying Earth systems. Through friendly competition and cooperation their efforts have established the San Francisco Bay Area as global leader in the green movement. The region consistently ranks at the top of lists for green job creation. The Bay area's venture capital community's investment in green technologies outpaces all other areas and many of the companies they invest in are located locally. The goal, as echoed by the workshop participants is to continue to stimulate this broad range of activities while building multiple, enduring connections between these stakeholders.

Additional workshops as well as the use of wiki's and other Web 2.0 tools need to be harnessed to facilitate ongoing interaction, information sharing and networking. This is especially important for regional players and stakeholders who can collaborate on joint projects and initiatives and undertake key demonstration programs. Programs like Cisco' Connected Urban Development Program (CUD) can then help scale and replicate viable programs effectively. The three original CUD cities (San Francisco, Seoul, and Amsterdam), for example, developed specific solutions to key urban sustainability issues in transportation, workplace structures, and citizen awareness of carbon footprints. Those three cities are now sharing their programs and new cities have been added to promote rapid exchange and deployment. We need to continue to fuel these individual activities as well as weave them together into a cross-linked portfolio.

To support this evolving community and guide their activities, we also need to assure that scientifically sound information is available, accessible, and useful to the issues facing sustainable urban development. On the one hand, this means investing in an observational capability that is more urban oriented – new satellites like CitySat. We lack the assets and missions dedicated to assessing the effects that cities have on the local and regional climate, air quality, ecosystem and human health. Two such mission concepts, CitySat and NightSat, were discussed at the workshop. On the other hand, it means harnessing already existing assets, such as the Earth Observing System or airborne laboratories. Several examples of leveraging current assets and missions, such as dovetailing the monitoring of California air quality with the artic survey mission NASA conducted in 2008, illustrate how current capabilities can be efficiently employed. Opportunities to develop new capabilities (e.g. NASA Venture class programs) or leverage upcoming missions need to be formally encouraged through program's like NASA's Applied Science Program or through collaborative projects funded by and conducted in conjunction with other agencies, private, municipal or state partners.

Along with observing cities from satellite, airborne or ground based systems and sensors, participants highlighted the need to make data more widely available and useful to potential users such as city planners. Here, the information technology industry's decades long development of tools and systems could be harnessed. Companies like Cisco are already leading the way with projects like Planetary Skin and the development of a platform that is a globally distributed, collaborative decision making tool. Currently the platform is being developed with NASA to demonstrate the monitoring and trading of carbon flows from rainforests, but the plan is to extend it into other critical biosphere systems. Considerable work is also underway in universities and other entities to develop geographical information systems to enable community-based climate change actions.

Lastly, the workshop participants emphasized the ultimate focus of these collective activities – to change people's behaviors. Considering the rate of rapid urbanization globally, cities and urban environments are a major component of the global climate system. Ultimately, our efforts are aimed at changing the way people live, work and play in cities. Bay Area cities are dedicated to enhancing green practices, such as recycling, installing energy efficient bulbs, using compressed natural gas and hybrid vehicles, using recycled wastewater for landscape irrigation, and providing incentives for green buildings. What counts is what works. Numerous projects, programs and initiatives need to be launched locally, then viable approaches can be spread globally. Programs like San Francisco's Urban EcoMap were applauded for informing and engaging city residents and workers to drive social behavior change and reduce energy consumption and green house gas production in a competitive and informative manner. Projects like this can focus on creating such change locally, assessing their effectiveness, improving results, then spreading globally.

By kindling a strong spirit of collaboration and a commitment to address the challenges together, the workshop was successful. An urban research agenda is needed to address the key technical issues. A community of researchers and practitioners is needed to plan, share and spread valuable programs. More accurate information on land cover classes, energy use, surface energy balances and urban heat-island effects is critical to guiding activity and assessing the impacts. Projects need to emphasize action and induce behavior change. If humanity is to have a sustainable future, we must reduce our Ecological Footprint.

Sustainable Urban Development Workshop Agenda

		DAY ONE Friday, January 9th	
Time	**Dur. min**	**Description**	**Speakers & Discussion leaders**
8:00	30	Breakfast	
8:30	5	Logistics	Stephanie Langhoff
8:35	10	Welcome/objectives	Pete Worden
8:45	15	Introduction of participants	Stephanie Langhoff, NASA Ames
9:00	20	NASA's Applied Sciences Program—Objectives and Approach	Teresa Fryberger, NASA Hqs.
Climate Change - Effects and Adaptation			**Steve Hipskind, NASA Ames**
9:20	15	Climate Change at the Regional Level: Prediction and Adaptation	Ed Sheffner, NASA Ames
9:35	15	NASA's Contributions in Detecting Urban Heat Islands Effects in Coastal Cities	Jorge Gonzalez, City University of New York
9:50	15	Urban Vulnerability to Climate Change: A Systems Dynamics Analysis	Tim Lant, Arizona State Univ.
10:05	10	Clarifying Discussion	
10:15	15	Break	
Policy Issues			**Gary Martin, NASA Ames**
10:30	15	Urban Sustainability Initiatives and NASA	Jared Blumenfeld, SF Dept. of
10:45	15	The Sustainability Challenge: One City's Green Brick Road	Melinda Hamilton, City of Sunnyvale
11:00	15	The 2030 Transportation Vision for the Bay Area Region	Dean Chu, Metropolitan Trans.Comm.
11:15	15	Using Remote Sensing to Coordinate Federal Mission Agency Studies of Urban Systems	Jonathan Fink, Arizona State Univ.
11:30	15	Integrating Renewables into the Power Grid	Serdar Uckun, Palo Alto Research Ctr.
11:45	25	Clarifying Discussion	
12:10	60	Lunch	
13:10	90	Discussion—Urban Management Café	Lori Lewis/ Jan Baxter, EPA
Urban Sustainability Tools/ Modeling			**Wolfgang Wagener, Cisco**
14:40	15	Humanity's Ecological Footprint	Meredith Stechbart, Global Footprint Network
14:55	15	System Dynamics of Urban Climate, Electricity, and Human Health Issues	Jonathan Fink, Arizona State Univ.
15:10	15	Planetary Skin: Global Distributed Collaborative Decision Engine for an Era of Uncertainty	Juan Carlos Castilla-Rubio, Cisco
15:25	15	Development Strategy Simulator	Martin Fischer, Stanford
15:40	15	Geographic Information Systems: Enabling Community-Based Climate Change Actions	Ryan Miller, CH2MHill
15:55	15	Swiss Service Gateway: Creating Internet Services based on 3D Modeling of the Built Environment of Switzerland	Ludger Hovestadt, Swiss Federal Institute of Technology Zurich
16:10	15	San Jose's Green Vision: Land Use Policy and Management	Laurel Prevetti, City of San Jose
16:25	10	Clarifying Discussion	
16:35	15	Break	
16:50	90	Discussion—Urban Management Café	Lori Lewis/ Jan Baxter, EPA
18:20		Adjorn	
19:00		DINNER: Chef Chu's, 1067 N San Antonio Rd, Los Altos	

Day two on next page

Sustainable Urban Development Workshop Agenda

		DAY TWO Saturday, January 10th	
Time	**Dur. (min)**	**Description**	**Speakers & Discussion leaders**
8:00	30	Breakfast	
Observations/Measurements			**Bob Chatfield, NASA Ames**
8:30	15	ARCTAS/CARB 2008: A Collaboration Between NASA and the California Air Resources Board Focused on California Air Quality and Climate	Hanwant Singh, NASA Ames
8:45	15	CitySat—A dedicated, Small-Mission Concept for Monitoring Urban Environments Worldwide	Phil Christensen, Arizona State Univ.
9:00	15	Using Satellite and Climate Models to Study Urban Heat Island and Aerosol Effects	Menglin Jin, San Jose State Univ.
9:15	15	Green Shift: Home Energy Management in Manchester and Other European Cities	Vin Sumner
9:30	10	Clarifying Discussion	
Land Use Management			**James Brass, NASA Ames**
9:40	15	Applied Sustainability: Using a Life Support Systems Approach at NASA Ames Research Center	Ann Clarke/Soheila Dianati, NASA Ames
9:55	15	Better Land Use Planning with NASA Data and Earth Science Models	Cristina Milesi, NASA Ames
10:10	15	NASA Science Serving Society: Improving Capabilities for Fire Characterization to Effect Reduction in Disaster Losses	Vince Ambrosia, NASA Ames
10:25	15	Break	
10:40	15	Mountain View's Sustainability Vision	Margaret Abe-Koga, City of Mtn. View
10:55	15	Using Remote Sensing to Facilitate and Accelerate a World Wide Urban Sustainability Collaboration	Harris Tiddens, t-systems
11:10	15	DEVELOP Internship Program for Earth Science	Jay Skiles, NASA Ames
11:25	10	Clarifying Discussion	
11:35	80	Discussion—Urban Management Café	Lori Lewis/ Jan Baxter, EPA
12:55	60	Lunch	
Water Resources and Air Quality Issues			**Jonathan Trent, NASA Ames**
13:55	15	Remote Sensing and Modeling of Carbon and Hydrologic Fluxes in Urbanized Watersheds	Chris Potter, NASA Ames
14:10	15	The Effects of Climate Change on Emissions and Ozone in Central California	Su-Tzai (Steve) Soong, Bay Area Air Quality Management District
14:25	15	Water Use Challenges in Santa Clara Valley	Hossein Ashktorab, Santa Clara Water District
14:40	15	Low Cost, Scalable Water Clarification	Meng Lean, Palo Alto Research Ctr.
14:55	35	Discussion—Water Resources and Air Quality Issues	
15:30	20	Break—acquire wine and cheese	
Roundtable Discussion- with wine and cheese			**Pete Worden, Director NASA Ames**
15:50	60	Topics: (1) What are the data and knowledge gaps for sustainable urban planning? (2)What are the opportunities for collaboration? (3) Research priorities- where do we go from here?	
16:50		Adjourn	

List of Participants

NAME	EMAIL	AFFILIATION
Ambrosia, Vince	vambrosia@mail.arc.nasa.gov	NASA ARC
Ashtktorab, Hossein	hashktorab@valleywater.org	Santa Clara Valley Water District
Barone, Lawrence	larry.barone@nasa.gov	NASA ARC
Biswas, Rupak	rupak.biswas@nasa.gov	NASA ARC
Blick, Don	Donald_blick@raytheon.com	Raytheon
Blumenfeld, Jared	jared.blumenfeld@sfgov.org	sfgov
Brass, James	james.a.brass@nasa.gov	NASA ARC
Bryant, Ronit	Ronit.Bryant@mountainview.gov	Mountain View
Castillo-Rubio, Juan Carlos	juanccas@cisco.com	Cisco
Chatfield, Robert	robert.b.chatfield@nasa.gov	NASA ARC
Christensen, Philip	phil.christensen@asu.edu	ASU
Chu, Dean	deanjchu@yahoo.com	Metropolitan Transportation Commission
Clarke, Anne	Ann.H.Clarke@nasa.gov	NASA ARC
Correll, Randy	rcorrell@ball.com	Ball
Dianati, Soheila	Soheila.Dianati@nasa.gov	NASA ARC
Fink, Jonathan	JONATHAN.FINK@asu.edu	ASU
Fischer, Martin	fischer@stanford.edu	Stanford
Franco, Guido	Gfranco@energy.state.ca.us	Green House gasses
Fryberger, Teresa	teresa.fryberger@nasa.gov	NASA Hq
Gardner, Andrea	agardner@ch2m.com	CH2M
Gonzalez-Cruz, Jorge	gonzalez@me.ccny.cuny.edu	CUNY
Hamilton, Melinda	council@melinda.org	Vice-Mayor Sunnyvale
Hipskind, Roderick	Steve.Hipskind@nasa.gov	NASA ARC
Hogan, John	John.A.Hogan@nasa.gov	NASA ARC
Hovestadt, Ludger	hovestadt@arch.ethz.ch	ETH Zurich
Inks, John	John.Inks@mountainview.gov	Mountain View
Jann, Martin	jann@arch.ethz.ch	ETH Zurich
Jin, Menglin	jin@met.sjsu.edu	SJSU

List continues on next page

List of Participants

NAME	EMAIL	AFFILIATION
Kasperzak, Michael	Michael.Kasperzak@mountainview.gov	Mountain View
Kass, Jennifer	Jennifer.Kass@sfgov.org	sfgov
Karcz, John	John.S.Karcz@nasa.gov	NASA ARC
Kiki, Said	skaki@jpl.nasa.gov	JPL
Langhoff, Stephanie	stephanie.r.langhoff@nasa.gov	NASA ARC
Lant, Tim	lant@asu.edu	ASU
La Rue, Anna	AMLe@PGE.COM	PGE
Lean, Meng	Meng.Lean@parc.com	PARC
Lewis, Lori	Lewis.Lori@epa.gov	EPA
Lockyer, Lisa	Lisa.L.Lockyer@nasa.gov	NASA ARC
Martin, Gary	Gary.L.Martin@nasa.gov	NASA ARC
McCauley, Eileen	emccaule@arb.ca.gov	CARB- air quality
McDonough, Karen	karen.mcdonough@sanjoseca.gov	City of San Jose
Melton, Forrest	Forrest.S.Melton@nasa.gov	NASA ARC
Milesi, Cristina	cristina.milesi-1@nasa.gov	NASA ARC
Miller,Ryan	Ryan.Miller@CH2M.com	CH2MHill
Ostrandere, Calla	Calla.Ostrander@sfgov.org	Dept. of Environment
Pelosi, Paul	ppelosijr@yahoo.com	SF Commissioner
Potter, Christopher	chris.potter@nasa.gov	NASA ARC
Prevetti, Laurel	Laurel.Prevetti@sanjoseca.gov	City of San Jose
Rajkovich, Nick	NBR4@pge.com	PGE
Ramakreshra, Nemani	Ramakrishna.R.Nemani@nasa.gov	NASA ARC
Saad, Katherine	K1Sz@pge.com	PGE
Sheffner, Edward	Edwin.J.Sheffner@nasa.gov	NASA ARC
Singh, Hanwant	hanwant.b.singh@nasa.gov	NASA ARC
Skiles, Jay	Joseph.W.Skiles@nasa.gov	NASA ARC
Soong, Steve	SSoong@baaqmd.gov	Bay Area Air Quality Management District
Stechbart, Meredith	Meredith@footprintnetwork.org	Global Footprint Network
Sumner, Vin	vin.sumner@clicksandlinks.com	Clicks and Links (England)

List of Participants

NAME	EMAIL	AFFILIATION
ten Hope, Laurie	Ltenhope@energy.state.ca.us	Advisor to Comm. Jeffrey Byron
Tiddens, Harris	Harris.Tiddens@t-online.de	t-systems
Trent, Jonathan	jonathan.d.trent@nasa.gov	NASA ARC
Uckun, Serdar	uckun@parc.com	PARC
Vanderbilt, Vern	Vern.C.Vanderbilt@nasa.gov	NASA ARC
Vargas, Kelaine	kelainevargas@urban-ecos.com	Urban Ecos
Vroman, Junko	junko.vroman@sanjoseca.gov	City of San Jose
Wagener, Wolfgang	wwagener@cisco.com	Cisco
Weightman, David	DWeightm@energy.state.ca.us	PIER (Sustainable communities)
Woodhouse, Kevin	kevin.woodhouse@mountainview.gov	Mountain View
Worden, Pete	Pete.Worden@nasa.gov	NASA ARC